**APPENDIX P-4**

**FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES**

**Survey Area:** BSA 02 **Description:** Building Survey Area (Building 230)

**Survey Unit:** 02 **Description:** Exterior Walls and Roof of Building 230

**Survey Type:** FSS **Classification:** Class 2

| Measurement or Sample ID | Surface or CSM | Type | Start Elevation | End Elevation | Northing (feet) (Y Axis) * | Easting (feet) (X Axis) * | Remarks / Notes |
|---|---|---|---|---|---|---|---|
| B02-02-01-S-W-S-00 | W | S | NA | NA | 13 | 115 | B230 West Wall |
| B02-02-02-S-W-S-00 | W | S | NA | NA | 34 | 157 | B230 West Wall |
| B02-02-03-S-W-S-00 | W | S | NA | NA | 15 | 11 | B230 East Wall |
| B02-02-04-S-W-S-00 | W | S | NA | NA | 7 | 183 | B230 South Wall |
| B02-02-05-S-W-S-00 | W | S | NA | NA | 19 | 19 | Cushman Room Roof |
| B02-02-06-S-W-S-00 | W | S | NA | NA | 6 | 60 | B230 Roof |
| B02-02-07-S-W-S-00 | W | S | NA | NA | 22 | 79 | B230 Roof |
| B02-02-08-S-R-S-00 | R | S | NA | NA | 60 | 148 | B230 Roof |
| B02-02-09-S-R-S-00 | R | S | NA | NA | 97 | 21 | B230 Roof |
| B02-02-10-S-R-S-00 | R | S | NA | NA | 110 | 119 | B230 Roof |
| B02-02-11-S-R-S-00 | R | S | NA | NA | 133 | 50 | B230 Roof |

*X and Y coordinates are provided using Missouri - East State Plane Coordinates [North American Datum (NAD) 1983] (Open Land Area)
Surface: Floor = F; Wall = W; Ceiling = C; Roof = R
CSM: Three-Layer (Surface-Root-Deep) or Uniform
Type: Systematic = S, Biased = B; QC =Q; Investigation = I

Quality Record

| Ludlum 2360 | Ludlum 43-89 | Active Probe Area | α HDP Efficiency | α Cal. Efficiency | ß HDP Efficiency | ß Cal. Efficiency |
|---|---|---|---|---|---|---|
| 297844 | 327409 | 125 $cm^2$ | **30.5%** | N/A | **19.6%** | N/A |

**TOTAL WEIGHTED INSTRUMENT EFFICIENCY CALCULATION**

| Radionuclide | Radiation | Maximum Energy (MeV) | Instrument Efficiency ($\varepsilon_i$) | Surface Efficiency ($\varepsilon_s$) | Yield 100% | Activity Fraction | Weighted Efficiency |
|---|---|---|---|---|---|---|---|
| **Am-241** | Alpha | 5.6 | 0.3046 | 0.25 | 1.00 | 2.682E-03 | 2.04E-04 |
| **Np-237** | Alpha | 5.0 | 0.3046 | 0.25 | 1.00 | 5.573E-05 | 4.24E-06 |
| **Pu-239** | Alpha | 5.2 | 0.3046 | 0.25 | 1.00 | 2.027E-06 | 1.54E-07 |
| **Tc-99** | Beta | 0.294 | 0.1961 | 0.25 | 1.00 | 2.829E-03 | 1.39E-04 |
| **Th-232** | Alpha | 4.1 | 0.3046 | 0.25 | 1.00 | 3.214E-03 | 2.45E-04 |
| **Ra-228** | Beta | 0.046 | 0.1961 | 0.00 | 1.00 | 3.214E-03 | 0.00E+00 |
| **Ac-228** | Beta | 2.13 | 0.1961 | 0.50 | 1.00 | 3.214E-03 | 3.15E-04 |
| **Th-228** | Alpha | 5.5 | 0.3046 | 0.25 | 1.00 | 3.214E-03 | 2.45E-04 |
| **Ra-224** | Alpha | 5.8 | 0.3046 | 0.25 | 1.00 | 3.214E-03 | 2.45E-04 |
| **U-234** | Alpha | 4.9 | 0.3046 | 0.25 | 1.00 | 8.270E-01 | 6.30E-02 |
| **U-235** | Alpha | 4.7 | 0.3046 | 0.25 | 1.00 | 3.720E-02 | 2.83E-03 |
| **Th-231** | Beta | 0.390 | 0.1961 | 0.25 | 1.00 | 3.720E-02 | 1.82E-03 |
| **U-238** | Alpha | 4.3 | 0.3046 | 0.25 | 1.00 | 1.270E-01 | 9.67E-03 |
| **Th-234** | Beta | 0.270 | 0.1961 | 0.25 | 1.00 | 1.270E-01 | 6.23E-03 |
| **Pa-234m** | Beta | 2.20 | 0.1961 | 0.50 | 1.00 | 1.270E-01 | 1.25E-02 |

**Total Weighted Instrument Efficiency = Σ Weighted Instrument Efficiency for all Nuclides of Concern** **Σ=** **9.74%**

**Weighted Instrument Efficiency = $\varepsilon_i$ * $\varepsilon_s$ * Yield * Activity Fraction**

**$\varepsilon_i$ = 2 Pi Instrument Efficiency for Nuclide of Concern**

**$\varepsilon_s$ = Surface Efficiency for Nuclide of Concern**

Meter
**43-93**

| | | | | Step 8.3.2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **MEASUREMENT ID** | **MEASUREMENT LOCATION** | **DATE MEAS** | **MEASUREMENT** | **GROSS cpm (α+β)** | **BKG cpm (a+b)** | **Net cpm (α + β)** | **Combined Net dpm/100 cm$^2$ (α+β)** | **Corrected Net dpm/100cm$^2$** | **Fraction of DCGL Step 8.4.3** |
| B02-02-01-S-W-S-00 | B230 West Wall | 04/27/2016 | alpha + beta TSC | 165 | 202 | -37 | -301 | 0 | 0% |
| B02-02-02-S-W-S-00 | B230 West Wall | 04/27/2016 | alpha + beta TSC | 189 | 202 | -13 | -104 | 0 | 0% |
| B02-02-03-S-W-S-00 | B230 East Wall | 04/27/2016 | alpha + beta TSC | 204 | 202 | 2 | 19 | 19 | 0% |
| B02-02-04-S-W-S-00 | B230 South Wall | 04/27/2016 | alpha + beta TSC | 182 | 202 | -20 | -162 | 0 | 0% |
| B02-02-05-S-W-S-00 | Cushman Room Roof | 04/27/2016 | alpha + beta TSC | 250 | 202 | 48 | 397 | 397 | 2% |
| B02-02-06-S-W-S-00 | B230 Roof | 04/27/2016 | alpha + beta TSC | 374 | 202 | 172 | 1415 | 1415 | 7% |
| B02-02-07-S-W-S-00 | B230 Roof | 04/27/2016 | alpha + beta TSC | 394 | 202 | 192 | 1580 | 1580 | 8% |
| B02-02-08-S-R-S-00 | B230 Roof | 04/27/2016 | alpha + beta TSC | 304 | 202 | 102 | 841 | 841 | 4% |
| B02-02-09-S-R-S-00 | B230 Roof | 04/27/2016 | alpha + beta TSC | 334 | 202 | 132 | 1087 | 1087 | 6% |
| B02-02-10-S-R-S-00 | B230 Roof | 04/27/2016 | alpha + beta TSC | 389 | 202 | 187 | 1539 | 1539 | 8% |
| B02-02-11-S-R-S-00 | B230 Roof | 04/27/2016 | alpha + beta TSC | 366 | 202 | 164 | 1350 | 1350 | 7% |

*NOTE: Differences from documented survey results are due to rounding in Excel

| | | | |
|---|---|---|---|
| Min | 0 | **4%** | Average Fraction Step 8.4.5.g |
| Max | 1580 | | |
| Mean | 748 | **DCGLso** | |
| Median | 841 | **1.00** | mrem SU Dose Contribution Step 8.4.6 |
| Stdev | 676.8 | **mrem** | |

Instrument used for FSS Static Measurements:

| | | | | | | |
|---|---|---|---|---|---|---|
| Ludlum 2360/43-89 | S/N 297844 | 04/27/2016 | | Survey # 7390 C 160427 | | |
| Detector Area (A) = | 125 $cm^2$ | ave. ambient bkg = ($\alpha + \beta$) | 202 cpm | weighted eff ($\varepsilon_w$)= | 0.09740 | |

TSC (dpm/100$cm^2$) = (gcpm-bkg) / ($\varepsilon_w$ * ($A_{det}$/100 $cm^2$))

DCGL (structures) = 18,925 dpm/100 $cm^2$

| MEASUREMENT ID | MEASUREMENT LOCATION | DATE MEAS | Alpha Gross cpm | Alpha Net cpm | Alpha Net dpm/100cm$^2$ | Corrected Alpha Net dpm/100cm$^2$ | Beta Gross cpm | Beta Net cpm | Beta Net dpm/100cm$^2$ | Corrected Beta Net dpm/100cm$^2$ | Combined Net dpm/100 cm$^2$ (α+β) | Exceed 10% of Min. Sys. TSC Result? | Exceed MDA? | Exceed 10% of DCGL? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | B230 West Wall | 04/27/2016 | 2 | 1 | 5 | 5 | 5 | 2 | 9 | 9 | 15 | Y | N | N |
| 2 | B230 West Wall | 04/27/2016 | 1 | 0 | 1 | 1 | 7 | 5 | 19 | 19 | 20 | Y | N | N |
| 3 | B230 East Wall | 04/27/2016 | 1 | 0 | 1 | 1 | 6 | 4 | 15 | 15 | 16 | Y | N | N |
| 4 | B230 South Wall | 04/27/2016 | 2 | 1 | 5 | 5 | 5 | 2 | 9 | 9 | 15 | Y | N | N |
| 5 | Cushman Room Roof | 04/27/2016 | 4 | 3 | 13 | 13 | 10 | 8 | 31 | 31 | 43 | Y | Y | N |
| 6 | B230 Roof | 04/27/2016 | 5 | 4 | 17 | 17 | 12 | 9 | 37 | 37 | 54 | Y | Y | N |
| 7 | B230 Roof | 04/27/2016 | 3 | 2 | 9 | 9 | 13 | 11 | 44 | 44 | 52 | Y | Y | N |
| 8 | B230 Roof | 04/27/2016 | 4 | 3 | 13 | 13 | 9 | 7 | 27 | 27 | 39 | Y | Y | N |
| 9 | B230 Roof | 04/27/2016 | 2 | 1 | 5 | 5 | 15 | 13 | 49 | 49 | 54 | Y | Y | N |
| 10 | B230 Roof | 04/27/2016 | 4 | 3 | 13 | 13 | 3 | 1 | 3 | 3 | 16 | Y | N | N |
| 11 | B230 Roof | 04/27/2016 | 2 | 1 | 5 | 5 | 4 | 1 | 6 | 6 | 11 | Y | N | N |

| | |
|---|---|
| Min | 11 |
| Max | 54 |
| Mean | 30 |
| Median | 20 |
| StDev | 18.0 |

DCGL = 18,925 dpm/100cm$^2$

Removable Activity (dpm/100cm$^2$) = (gcpm-bkg) / ε

Area "swiped" = 100 cm$^2$

Instrument used for Removable Measurements:

Tennelec Unit # 1 Cal Due 9/11/16 Survey # 7390 C 160427

| | | | | | |
|---|---|---|---|---|---|
| alpha bkα = | 0.7 cpm | alpha efficiency = | 25.30% | alpha MDA = | 13.7 |
| beta bkg = | 2.1 cpm | beta efficiency = | 25.40% | beta MDA = | 22 |

| Sign Test | | | | | |
|---|---|---|---|---|---|
| **SAMPLE ID** | **SAMPLE ID** | **Gross TSC Step 8.5.4.a** | **Gross TSC / Adj. Gross DCGL ($W_s$) Step 8.5.4.b** | **Difference ($1-W_s$) Step 8.5.4.d** | **Corrected Difference Step 8.5.4.e** |
| B02-02-01-S-W-S-00 | B230 West Wall | 0 | 0.000 | 1.000 | 1.000 |
| B02-02-02-S-W-S-00 | B230 West Wall | 0 | 0.000 | 1.000 | 1.000 |
| B02-02-03-S-W-S-00 | B230 East Wall | 19 | 0.001 | 0.999 | 0.999 |
| B02-02-04-S-W-S-00 | B230 South Wall | 0 | 0.000 | 1.000 | 1.000 |
| B02-02-05-S-W-S-00 | Cushman Room Roof | 397 | 0.021 | 0.979 | 0.979 |
| B02-02-06-S-W-S-00 | B230 Roof | 1415 | 0.075 | 0.925 | 0.925 |
| B02-02-07-S-W-S-00 | B230 Roof | 1580 | 0.083 | 0.917 | 0.917 |
| B02-02-08-S-R-S-00 | B230 Roof | 841 | 0.044 | 0.956 | 0.956 |
| B02-02-09-S-R-S-00 | B230 Roof | 1087 | 0.057 | 0.943 | 0.943 |
| B02-02-10-S-R-S-00 | B230 Roof | 1539 | 0.081 | 0.919 | 0.919 |
| B02-02-11-S-R-S-00 | B230 Roof | 1350 | 0.071 | 0.929 | 0.929 |
| **Number of Positive Differences (S+)** | | | | | 11 |
| **Sign Test Critical Value (MARSSIM Table I-3)** | | | | | **8** |

If every measurement in the systematic sample population is <= the DCGL, a statistical test is not required.

**TEST:** **PASS**

$\alpha = 0.05$

| **MARSSIM Table I-3 Critical Values for the Sign Test Statistic S+** | | **MARSSIM Table I-3 Critical Values for the Sign Test Statistic S+** | |
|---|---|---|---|
| **N** | **Alpha = 0.05** | **N** | **0.05** |
| 4 | 4 | 28 | 18 |
| 5 | 4 | 29 | 19 |
| 6 | 5 | 30 | 19 |
| 7 | 6 | 31 | 20 |
| 8 | 6 | 32 | 21 |
| 9 | 7 | 33 | 21 |
| 10 | 8 | 34 | 22 |
| 11 | 8 | 35 | 22 |
| 12 | 9 | 36 | 23 |
| 13 | 9 | 37 | 23 |
| 14 | 10 | 38 | 24 |
| 15 | 11 | 39 | 25 |
| 16 | 11 | 40 | 25 |
| 17 | 12 | 41 | 26 |
| 18 | 12 | 42 | 26 |
| 19 | 13 | 43 | 27 |
| 20 | 14 | 44 | 27 |
| 21 | 14 | 45 | 28 |
| 22 | 15 | 46 | 29 |
| 23 | 15 | 47 | 29 |
| 24 | 16 | 48 | 30 |
| 25 | 17 | 49 | 30 |
| 26 | 17 | 50 | 31 |
| 27 | 18 | | |