



**Advanced Measurement Technology, Inc.**



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Technical Note

RE: MDA Values for Isotopic (ISOPLUS) Systems

We are often asked to provide “typical” minimum detectable activity (MDA) levels achievable with ISO-CART systems or with ORTEC HPGe detectors and Isotopic (ISOPLUS) software.

In the attached tables are typical detection levels assuming normal facility backgrounds for two detector sizes. The measurements assume recommended counting positions for a 208-liter drum and a B-25 box. Two commonly used densities and matrices are included. An additional table is included for Marinelli beakers.

Other MDA values for specified configurations can be computed upon request. In order to compute the activity from a particular detector, a background spectrum and a calibration spectrum are needed.

Sincerely,

Richard Hagenauer

**208-liter and B-25 Box MDA Values for a 28% GEM detector /Collimated**

Counting time = 1.0 hr; MDA method = Nureg 4.16

October 17, 2003

Diameter: 59 mm

Length: 47 mm

| 208-Liter Drum<br>Detector positioned 46 cm (18 inches) from drum |                  |  |          |          |  |          |          |
|---|------------------|--|----------|----------|--|----------|----------|
| Nuclide   | Ref Energy (keV) | Combustible Density 0.2 g/cc<br>Wt = 4.16E+4 g |          |          | Metal Density = 1.0 g/cc<br>Wt = 2.08E+5 g |          |          |
|   |                  | Grams  | pCi/g    | Bq/kg    | Grams                                      | pCi/g    | Bq/kg    |
| Co-60   | 1332.5           |  | 6.36E-01 | 2.35E+01 |  | 2.62E-01 | 9.71E+00 |
| Cs-137  | 661.6            |  | 2.43E-01 | 8.98E+00 |  | 1.22E-01 | 4.50E+00 |
| Ra-226  | 609.3            |  | 5.24E-01 | 1.94E+01 |  | 2.66E-01 | 9.86E+00 |
| U-235   | 185.7            | 7.96E-03                                       | 3.72E-01 | 1.37E+01 | 3.08E-02                                   | 2.88E-01 | 1.06E+01 |
| U-238   | 1001.0           | 3.54E+00                                       | 2.55E+01 | 9.43E+02 | 8.00E+00                                   | 1.15E+01 | 4.26E+02 |
| Np-237  | 312.2            | 2.80E-05                                       | 4.28E-01 | 1.58E+01 | 8.24E-05                                   | 2.50E-01 | 9.26E+00 |
| Pu-238  | 152.7            | 7.16E-05                                       | 2.64E+04 | 9.78E+05 | 3.33E-04                                   | 2.46E+04 | 9.12E+05 |
| Pu-239  | 413.7            | 8.44E-03                                       | 1.13E+04 | 4.19E+05 | 2.31E-02                                   | 6.20E+03 | 2.29E+05 |
| Pu-240  | 160.31           | 1.19E-02                                       | 5.84E+04 | 2.16E+06 | 5.28E-02                                   | 5.16E+04 | 1.91E+06 |
| Pu-241  | 208.0            | 2.02E-05                                       | 4.28E+04 | 1.58E+06 | 7.16E-05                                   | 3.03E+04 | 1.12E+06 |
| Am-241  | 59.5             |  | 3.46E+00 | 1.28E+02 |  | 1.75E+01 | 6.47E+02 |
| Cm-243  | 277.6            |  | 1.53E+00 | 5.67E+01 |  | 9.36E-01 | 3.46E+01 |
| Cm-244  | 152.6            | 1.45E-05                                       | 2.54E+04 | 9.40E+05 | 6.76E-05                                   | 2.37E+04 | 8.76E+05 |

| B-25 Box (183 x 122 x 122 cm - 72 x 48 x 48 in)<br>Detector positioned 91 cm (36 inches) from box |                  |   |          |          |  |          |          |
|---|------------------|---|----------|----------|--|----------|----------|
| Nuclide   | Ref Energy (keV) | Combustible Density 0.2 g/cc<br>Wt = 5.44 E+5 g |          |          | Metal Density = 1.0 g/cc<br>Wt = 2.72E+6 g |          |          |
|   |                  | Grams   | pCi/g    | Bq/kg    | Grams                                      | pCi/g    | Bq/kg    |
| Co-60   | 1332.5           |   | 3.54E-01 | 1.31E+01 |  | 2.37E-01 | 8.76E+00 |
| Cs-137  | 661.6            |   | 1.53E-01 | 5.65E+00 |  | 1.18E-01 | 4.37E+00 |
| Ra-226  | 609.3            |   | 8.64E-01 | 3.20E+01 |  | 2.60E-01 | 9.61E+00 |
| U-235   | 185.7            | 7.48E-02  | 2.97E-01 | 1.10E+01 | 3.82E-01                                   | 3.04E-01 | 1.12E+01 |
| U-238   | 1001.0           | 2.43E+01  | 1.49E+01 | 5.51E+02 | 8.80E+01                                   | 1.08E+01 | 3.98E+02 |
| Np-237  | 312.2            | 2.38E-04  | 3.09E-01 | 1.14E+01 | 9.80E-04                                   | 6.56E-01 | 2.43E+01 |
| Pu-238  | 152.7            | 7.04E-04  | 7.76E+03 | 2.87E+05 | 4.24E-03                                   | 2.68E+04 | 9.90E+05 |
| Pu-239  | 413.7            | 6.80E-02  | 2.41E+04 | 8.91E+05 | 2.71E-01                                   | 6.16E+03 | 2.28E+05 |
| Pu-240  | 160.31           | 1.15E-01  | 4.84E+04 | 1.79E+06 | 6.64E-01                                   | 1.08E+05 | 3.98E+06 |
| Pu-241  | 208.0            | 1.85E-04  | 3.33E+04 | 1.23E+06 | 8.80E-04                                   | 3.17E+04 | 1.17E+06 |
| Am-241  | 59.5             |   | 6.20E+00 | 2.29E+02 |  | 3.78E+01 | 1.40E+03 |
| Cm-243  | 277.6            |   | 1.13E+00 | 4.19E+01 |  | 9.56E-01 | 3.54E+01 |
| Cm-244  | 152.6            | 1.43E-04  | 2.13E+04 | 7.87E+05 | 8.64E-04                                   | 2.57E+04 | 9.52E+05 |

For a 15-minute count increase the MDA by  $\text{Sqrt}(3600\text{sec}/900\text{sec}) = \text{Sqrt}(4) = 2.0$

**208-liter and B-25 Box MDA Values for a 78% GMX detector /Collimated**

Counting time = 1.0 hr; MDA method = Nureg 4.16

Weight of the container is not included in the pCi/g (Bq/kg) estimate.

October 17, 2003

Diameter: 70.2 mm

Length: 89.9 mm

| 208-Liter Drum<br>Detector positioned 46 cm (18 inches) from drum |                  |  |          |          |  |          |          |
|---|------------------|--|----------|----------|--|----------|----------|
| Nuclide   | Ref Energy (keV) | Combustible Density 0.2 g/cc<br>Wt = 4.16E+4 g |          |          | Metal Density = 1.0 g/cc<br>Wt = 2.08E+5 g |          |          |
|   |                  | Grams  | pCi/g    | Bq/kg    | Grams                                      | pCi/g    | Bq/kg    |
| Co-60   | 1332.5           |  | 4.80E-02 | 1.78E+00 |  | 1.99E-02 | 7.36E-01 |
| Cs-137  | 661.6            |  | 1.58E-01 | 5.85E+00 |  | 7.94E-02 | 2.94E+00 |
| Ra-226  | 609.3            |  | 3.82E-01 | 1.41E+01 |  | 1.94E-01 | 7.19E+00 |
| U-235   | 185.7            | 6.03E-03                                       | 2.81E-01 | 1.04E+01 | 2.34E-02                                   | 2.18E-01 | 8.07E+00 |
| U-238   | 1001.0           | 2.72E+00                                       | 1.97E+01 | 7.27E+02 | 6.16E+00                                   | 8.86E+00 | 3.28E+02 |
| Np-237  | 312.2            | 2.05E-05                                       | 3.12E-01 | 1.15E+01 | 6.01E-05                                   | 1.83E-01 | 6.77E+00 |
| Pu-238  | 152.7            | 2.31E-05                                       | 8.51E+03 | 3.15E+05 | 1.07E-04                                   | 7.92E+03 | 2.93E+05 |
| Pu-239  | 413.7            | 7.40E-03                                       | 9.91E+03 | 3.67E+05 | 2.02E-02                                   | 5.41E+03 | 2.00E+05 |
| Pu-240  | 160.31           | 6.49E-03                                       | 3.20E+04 | 1.18E+06 | 2.87E-02                                   | 2.83E+04 | 1.05E+06 |
| Pu-241  | 208.0            | 1.54E-05                                       | 3.25E+04 | 1.20E+06 | 5.48E-05                                   | 2.32E+04 | 8.57E+05 |
| Am-241  | 59.5             |  | 1.20E+00 | 4.43E+01 |  | 6.07E+00 | 2.25E+02 |
| Cm-243  | 277.6            |  | 1.28E+00 | 4.72E+01 |  | 7.80E-01 | 2.88E+01 |
| Cm-244  | 152.6            | 4.66E-06                                       | 8.14E+03 | 3.01E+05 | 2.17E-05                                   | 7.58E+03 | 2.81E+05 |

| B-25 Box (183 x 122 x 122cm - 72 x 48 x 48 in)<br>Detector positioned 91 cm (36 inches) from box |                  |   |          |          |  |          |          |
|--|------------------|---|----------|----------|--|----------|----------|
| Nuclide  | Ref Energy (keV) | Combustible Density 0.2 g/cc<br>Wt = 5.44 E+5 g |          |          | Metal Density = 1.0 g/cc<br>Wt = 2.72E+6 g |          |          |
|  |                  | Grams   | pCi/g    | Bq/kg    | Grams                                      | pCi/g    | Bq/kg    |
| Co-60  | 1332.5           |   | 2.68E-02 | 9.91E-01 |  | 1.79E-02 | 6.61E-01 |
| Cs-137   | 661.6            |   | 9.98E-02 | 3.69E+00 |  | 7.71E-02 | 2.85E+00 |
| Ra-226   | 609.3            |   | 2.44E-01 | 9.03E+00 |  | 1.90E-01 | 7.02E+00 |
| U-235  | 185.7            | 5.66E-02  | 2.25E-01 | 8.32E+00 | 2.89E-01                                   | 2.31E-01 | 8.53E+00 |
| U-238  | 1001.0           | 1.88E+01  | 1.14E+01 | 4.22E+02 | 6.77E+01                                   | 8.29E+00 | 3.07E+02 |
| Np-237   | 312.2            | 1.74E-04  | 2.26E-02 | 8.36E-01 | 7.15E-04                                   | 1.85E-01 | 6.86E+00 |
| Pu-238   | 152.7            | 2.26E-04  | 7.12E+03 | 2.63E+05 | 1.37E-03                                   | 8.60E+03 | 3.18E+05 |
| Pu-239   | 413.7            | 5.97E-02  | 6.80E+03 | 2.52E+05 | 2.36E-01                                   | 5.40E+03 | 2.00E+05 |
| Pu-240   | 160.31           | 6.29E-02  | 2.64E+04 | 9.78E+05 | 1.88E-01                                   | 3.04E+04 | 1.12E+06 |
| Pu-241   | 208.0            | 1.41E-04  | 2.54E+04 | 9.41E+05 | 6.71E-04                                   | 2.42E+04 | 8.95E+05 |
| Am-241   | 59.5             |   | 2.15E+00 | 7.94E+01 |  | 1.31E+01 | 4.85E+02 |
| Cm-243   | 277.6            |   | 9.44E-01 | 3.49E+01 |  | 7.97E-01 | 2.95E+01 |
| Cm-244   | 152.6            |   | 2.68E-02 | 9.91E-01 | 2.77E-04                                   | 8.23E+03 | 3.04E+05 |

For a 15-minute count increase the MDA by  $\text{Sqrt}(3600\text{sec}/900\text{sec}) = \text{Sqrt}(4) = 2.0$

**1-Liter Marinelli Beaker MDA Values for a 40% GMX Detector**

Counting time = 1.0 hr; MDA method = Nureg 4.16

6/08/03

| Nuclide       | Ref Energy (keV) | Plastic Resin Density 1.0 g/cc |          |          |
|---------------|------------------|--------------------------------|----------|----------|
|               |                  | Grams                          | pCi/g    | Bq/kg    |
| <b>Co-60</b>  | 1332.5           |                                | 1.79E-02 | 6.64E-01 |
| <b>Cs-137</b> | 661.6            |                                | 5.72E-02 | 2.12E+00 |
| <b>Ra-226</b> | 609.3            |                                | 1.11E-01 | 4.09E+00 |
| <b>U-235</b>  | 185.7            | 2.19E-06                       | 4.27E-02 | 1.58E+00 |
| <b>U-238</b>  | 1001.0           | 1.79E-03                       | 5.14E+00 | 1.90E+02 |
| <b>Np-237</b> | 312.2            | 1.70E-08                       | 1.08E-01 | 3.98E+00 |
| <b>Pu-238</b> | 152.7            | 1.72E-08                       | 2.63E+03 | 9.73E+04 |
| <b>Pu-239</b> | 413.7            | 5.29E-06                       | 2.95E+03 | 1.09E+05 |
| <b>Pu-240</b> | 160.31           | 4.78E-06                       | 9.79E+03 | 3.62E+05 |
| <b>Pu-241</b> | 208.0            | 9.40E-09                       | 8.29E+03 | 3.07E+05 |
| <b>Am-241</b> | 59.5             | 3.18E-12                       | 9.78E-02 | 3.62E+00 |
| <b>Cm-243</b> | 277.6            |                                | 3.08E-01 | 1.14E+01 |
| <b>Cm-244</b> | 152.6            | 3.45E-09                       | 2.51E+03 | 9.30E+04 |

For water sample the MDA values will be the same

For soil samples the MDA values will be slightly higher

For 0.5 liter beakers the MDA values will be slightly higher

For 2.0 liter beakers the MDA values will be slightly lower (improve)

For a 15-minute count increase the MDA by  $\text{Sqrt}(3600\text{sec}/900\text{sec}) = \text{Sqrt}(4) = 2.0$

**Well Detector MDA Values for 120 cc Volume by 15 mm diameter hole**

Counting time = 100,000 sec; MDA method = NuReg 4.16

Detector shielded

Matrix water; vial diameter = 12 mm

5/23/07

| <b>Nuclide</b> | <b>Ref Energy (keV)</b> | <b>Bq</b> |
|----------------|-------------------------|-----------|
| <b>Co-60</b>   | 1332.5                  | 9.14E-3   |
| <b>Cu-64</b>   | 511                     | 3.60E-2   |
| <b>Cs-137</b>  | 661.6                   | 1.26E-2   |
| <b>Pb-210</b>  | 46.5                    | 4.33E-2   |
| <b>Ra-226</b>  | 609.3                   | 2.19E-2   |
| <b>U-235</b>   | 185.7                   | 1.19E-2   |
| <b>U-238</b>   | 1001.0                  | 7.48E-1   |
| <b>Np-237</b>  | 312.2                   | 1.72E-2   |
| <b>Pu-238</b>  | 152.7                   | 6.42E+2   |
| <b>Pu-239</b>  | 129.28                  | 8.03E+1   |
| <b>Am-241</b>  | 59.5                    | 5.32E-3   |

Actual MDA values may vary depending on the counting time, MDA method, and lead shield.