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February 24, 2015

U.S. Nuclear Regulatory Commission
Region III Office
2443 Warrenville Road, Suite 210
Lisle, IL 60532-4352

Attn: Mr. Kevin Null
Subj: Clarifications to the Combined Application for a License to Produce and Possess Accelerator Produced Radionuclides for Research and Development (NRC Control No. 584728)

Mr. Null:
Below you will find our clarifications to the upgraded RAM storage room, separating fission products from the uranium target, and estimates of the incidentally produced radionuclides.

1. RAM Upgrade

Niowave has completed an upgrade to our RAM storage enclosure. We have fully enclosed the storage area with solid walls and a roof as well as a lockable chain-link gate (see Figures 1-4). The gate can only be accessed thru the spectroscopy lab, which is locked at all times when not occupied by applied physics personnel. Originally there was only a single layer of chain-link wall and no roof enclosing the storage area. The RAM storage vault is now among the most secure locations in our facility. Images of the upgraded enclosure can be found in the figures below.

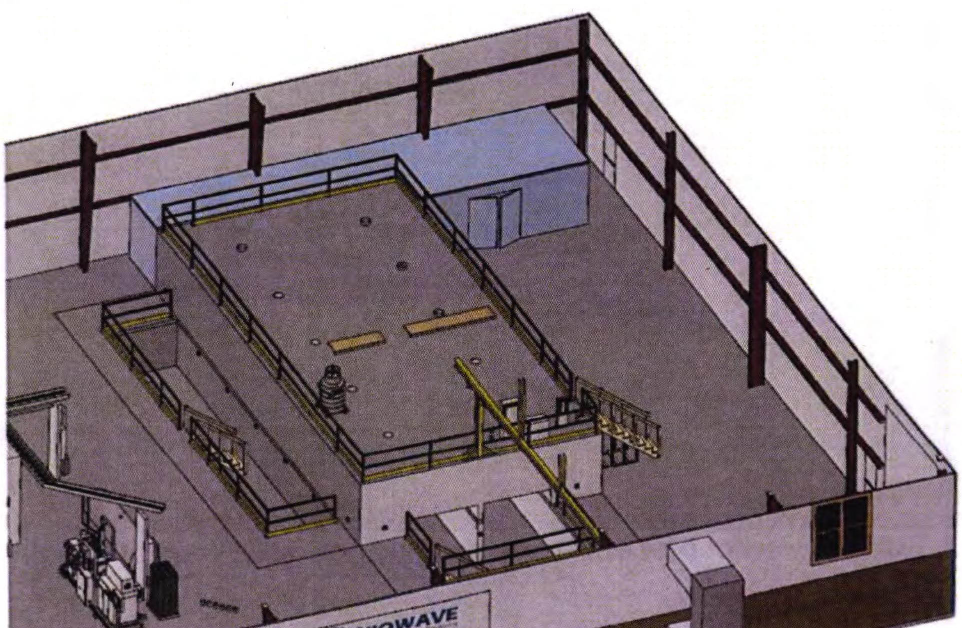

Figure 1: Drawing showing external of RAM Storage and Spectroscopy Lab enclosure.

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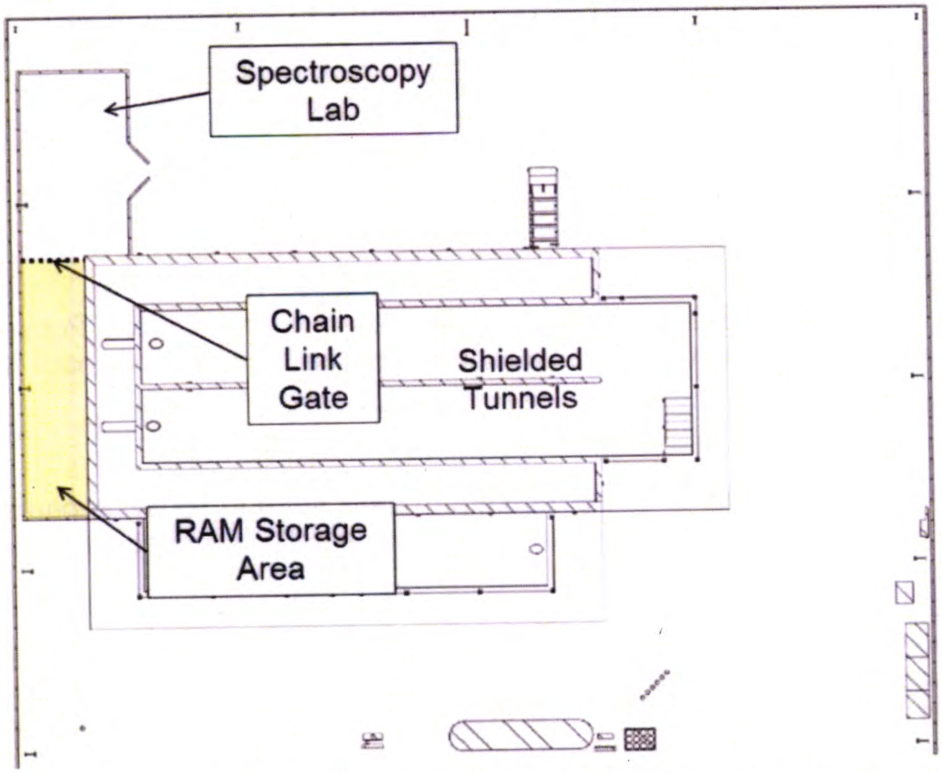

Figure 2: Overhead view of the eastern half of the NERD building showing the new enclosure.

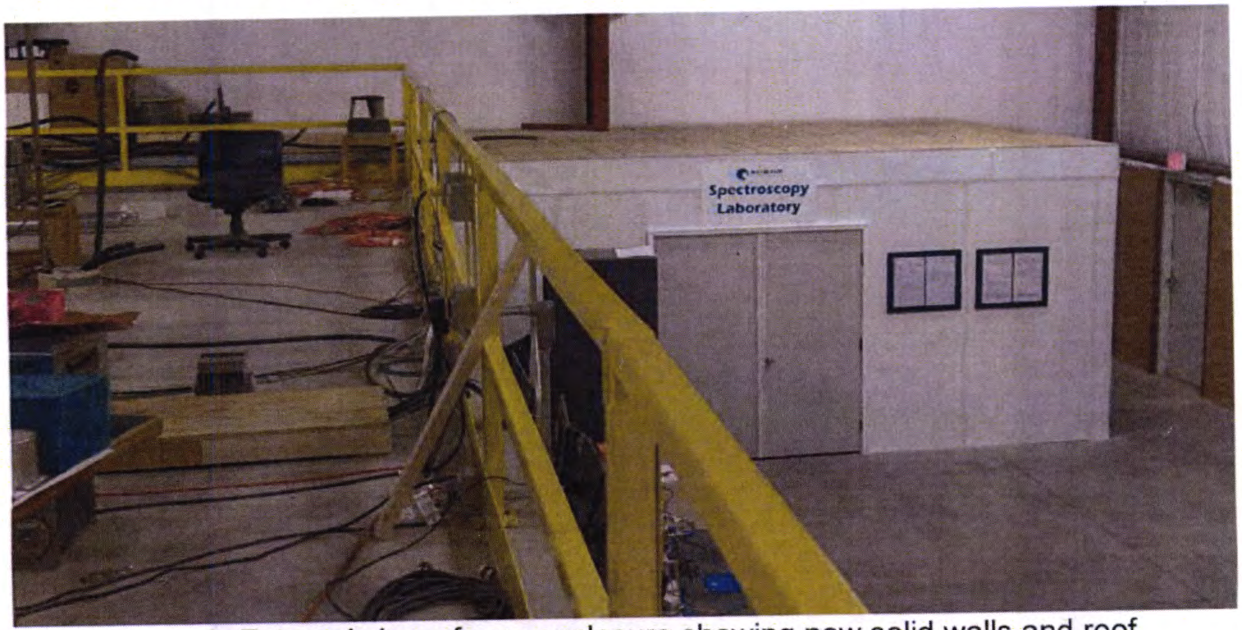

Figure 3: External view of new enclosure showing new solid walls and roof.

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Figure 4: View from Spectroscopy Lab looking into locked RAM Storage Area.

2. Separation of fission products from the irradiated uranium target

Metal uranium targets (natural, depleted, or enriched) will be cladded before being irradiated. After the irradiation, fission fragments will not be separated from the targets by any physical or chemical methods.

3. Incidentally produced radionuclides

Incidentally produced short-lived isotopes

While producing radioisotopes both from the stable targets and from uranium targets a number of short lived ($T_{1/2}$ <120 days) isotopes will be produced. The total combined activity of all the short-lived incidentally produced radioisotopes will not exceed the catch-all possession limit of 15 mCi.

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Long-lived radionuclides incidentally produced from stable targets

Several long-lived ($T_{1/2}$ >120 days) isotopes can be produced while irradiating natural gold, holmium, iridium, manganese, molybdenum, scandium, selenium, strontium, titanium, zinc, and yttrium targets (see Table 1).

Table1. Possible incidentally produced long-lived ($T_{1/2}$ >120 days) isotopes, their half-lives, and exempt activities.

Isotope	Half-life	Exempt activity, µCi (10 CFR § 30.71 Schedule B)
Gold-195	183 d	10
Holmium-166m	1,200 y	0.1
Iridium-192m	242 y	0.1
Iridium-194m	171 d	0.1
Manganese-54	312 d	10
Molybdenum-93	4,000 y	0.1
Molybdenum-97	$3\mathrm{x}10^6$ y	0.1
Niobium-91	680 y	0.1
Niobium-93m	16 y	10
Technicium-99	$2\mathrm{x}10^5$ y	10

To estimate the activity of incidentally produced long-lived isotopes let's consider Ir-192 production as an example. Whenever Ir-192 is produced (either via $^{193}Ir(\gamma,n)^{192}Ir$ or $^{191}Ir(n,\gamma)^{192}$ route), it is accompanied by Ir-192m. The Ir-192m yield was estimated using a 1 hour irradiation of a natural yttrium target with a 40 MeV electron beam. Our calculations show that production of 1 mCi of Ir-192 will result in less than 0.1 µCi of Ir-192m, which is below the exempt threshold. Similar calculations were done for all of the above long-lived radionuclides and we are certain that the activity of each of the radioisotopes from Table 1 possessed by Niowave will not exceed the exempt quantities.

Long-lived radionuclides incidentally produced from natural, depleted, and low-enriched uranium

While producing radioisotopes from natural, depleted, or low-enriched uranium, a number of fission products will be produced, many of them being long-lived ($T_{1/2}$ >120 days). However, due to short irradiation periods we are planning to perform (not to exceed few hours), the activity of these long-lived species will be negligible. As an example, we consider one of the most common fission products, Cs-137 ($T_{1/2}$=30.1 years) and calculate its yield from a 1 hour irradiation of uranium. To produce 1 mCi of Mo-99 in one hour, its production rate should be:

$$\left(\frac{dN}{dt}\right)_{Mo-99} = 3.7\times10^9 s^{-1}$$

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The Cs-137 production rate is comparable to the Mo-99 production rate (7% vs. 6% of fissions) and the activity of the Cs-137 after 1 hour irradiation will be:

$$Y = \left(\frac{dN}{dt}\right)_{Cs-137}\left(1-e^{-\lambda t}\right) = 4\times10^{9}s^{-1}\times\left(1-e^{-\frac{\ln(2)\times 1h}{30.1y}}\right) = 10^{4}s^{-1} = 10kBq \approx 280nCi$$

This activity is so low that it barely increases the R-value. In fact, we calculated the maximum activity of Cs-137 that would require Niowave to increase our financial assurance value and found it to be about 0.2 mCi (see Table 2). This is about 1,000 higher than the amount of Cs-137 we would generate in the above example to produce 1 mCi of Mo-99. We understand that other long-lived isotopes will contribute to the R-value as well, but we are certain that even the cumulative yield of all fission products will still keep us under the current FA level of $225k.

Table 2. R-values taking into account 0.2 mCi of Cs-137.

U-235 Enrichment (%)	LEU Mass (g)	U-234 Mass (g)	U-235 Mass (g)	U-238 Mass (g)	Cs-137 activity (mCi)	Zn-65 activity (mCi)	$225,000 FA R-value
10.00	23.3	1.5E-02	2.3	21.0	0.2	1	0.999
11.00	21.0	1.5E-02	2.3	18.7	0.2	1	0.997
12.00	19.1	1.5E-02	2.3	16.8	0.2	1	0.996
13.00	17.5	1.5E-02	2.3	15.2	0.2	1	0.996
14.00	16.2	1.5E-02	2.3	13.9	0.2	1	1.000
15.00	15.0	1.5E-02	2.3	12.8	0.2	1	0.999
16.00	13.9	1.5E-02	2.2	11.7	0.2	1	0.994
17.00	13.0	1.5E-02	2.2	10.8	0.2	1	0.995
18.00	12.2	1.5E-02	2.2	10.0	0.2	1	0.996
19.00	11.5	1.5E-02	2.2	9.3	0.2	1	0.998
19.75	11.0	1.5E-02	2.2	8.8	0.2	1	0.998

We hope the above information on the upgraded RAM storage room, separating fission products from the uranium target, and estimates of the incidentally produced radionuclides is helpful. If you have any further questions please let us know.

Sincerely,

Dr. Terry L. Grimm, Ph.D.
President and Senior Scientist

Null, Kevin

From: Valeriia Starovoitova <valeriia@niowaveinc.com>
Sent: Tuesday, February 24, 2015 3:34 PM
To: Null, Kevin
Cc: Dr. Terry Grimm; maddock@niowaveinc.com
Subject: Clarifications to the combined application for a license to produce and possess accelerator produced radionuclides foe research and development (NRC control number 584728)
Attachments: NRC Clarification Letter (signed) 150224.pdf

Dear Kevin,

Attached is a letter which addresses the three questions you asked us to clarify:

1. Upgrade of the RAM storage area
2. Our intentions to keep the target intact and not to separate any fission products from the uranium targets 3. Estimates of the incidentally produced radioisotopes

Also, we stopped the second letter from the bank as you advised. I hope the first letter (which went to Rockville, MD) will be tracked down soon.

We'll be happy to answer any further questions.
Sincerely,
Valeriia

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Dr. Valeriia Starovoitova
Nuclear Physicist
Niowave, Inc