

NIOWAVE, INC.

1012 North Walnut Street
Lansing, MI 48906
Phone: (517) 999-3475

March 5th, 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 estimates of the incidentally produced radionuclides.

Incidentally produced radionuclides

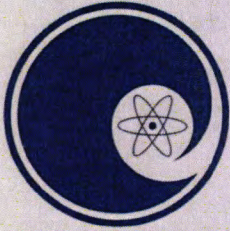
Radionuclides incidentally produced from stable targets

While producing radioisotopes from the stable targets a number of short lived ($T_{1/2} < 120$ days) isotopes will be produced. The total activity of all the short-lived incidentally produced radioisotopes possessed by Niowave will not exceed 15 mCi.

In addition, 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).

Table 1. 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	3×10^6 y	0.1
Niobium-91	680 y	0.1
Niobium-93m	16 y	10
Technicium-99	2×10^5 y	10



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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 $^{193}\text{Ir}(\gamma, n)^{192}\text{Ir}$ or $^{191}\text{Ir}(n, \gamma)^{192}\text{Ir}$ 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.

Radionuclides incidentally produced from natural, depleted, and low-enriched uranium

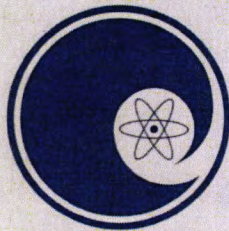
While producing radioisotopes from natural, depleted, or low-enriched uranium, a number of fission products will be produced, many of them being long-lived ($T_{1/2} > 120$ days). However, due to short irradiation periods we are planning to perform (not to exceed few hours), the activity of these long-lived 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

$$\left(\frac{dN}{dt}\right)_{\text{Mo-99}} = 3.7 \times 10^9 \text{ s}^{-1}$$

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:

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

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.



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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

Summary

The total activity of all the short-lived incidentally produced radioisotopes ($T_{1/2} < 120$ days) possessed by Niowave (from irradiating both stable and uranium targets) will not exceed 15 mCi.

Activity of each individual long-lived incidentally produced radioisotope ($T_{1/2} > 120$ days) possessed by Niowave will not exceed 1 μ Ci. The total activity of all the long-lived incidentally produced radioisotopes possessed by Niowave will not exceed 1 mCi. At the same time, the activities of different long-lived radioisotopes will be such that the calculated R-value will keep Niowave under the current financial assurance level of \$225k.

We hope the above information on the 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: Thursday, March 05, 2015 12:58 PM
To: Null, Kevin
Cc: Dr. Terry Grimm; maddock@niowaveinc.com
Subject: Re: Clarifications to the combined application for a license to produce and possess accelerator produced radionuclides for research and development (NRC control number 584728)
Attachments: NRC Clarification Letter (signed) 150305.pdf

Dear Kevin,

Attached is a letter which addresses the issues you and I discussed yesterday. The only part of the document which is different from the previous version is the Summary, where I specified individual and cumulative activities of long-lived incidentally produced radioisotopes.

The hard copy of this document will be mailed to your office later today. Please let me know if anything else is needed.

Sincerely,

Valeriia

PS. The standby trust agreement was signed today and mailed to your office overnight. I assume the letter of credit is in your hands by now, so hopefully tomorrow you'll have all the paperwork from the bank you need!

On 2/24/2015 4:33 PM, Valeriia Starovoitova wrote:

> 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