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Calc-Note Number: CN-LANSCEFM-02-004

Title: WNR Target 4 Radionuclide Inventory Calculation for Start of the 2002 Run Cycle

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Signature

Date

Reviewer: Jeff Bull

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Date

Summary:

A Target 4 radionuclide inventory calculation was completed for irradiation of the "new" target during the 2001 run cycle. The maximum Hazard Category 3 threshold ratio was 0.37 on 11/25/01. Combined with the "old" target inventory as previously evaluated, the maximum threshold ratio was 0.98. The "old" target was removed during the 2002 outage, and going into the 2002 run cycle, the Hazard Category 3 threshold ratio for the "new" target is less than ten percent. Integrated beam current limits were determined for continued irradiation of the target. Assuming that a maximum beam current of 5 μA is established, the integrated beam current limit is 25,088 μA -hours. Selection of a higher maximum beam current will require a lower integrated beam current limit. Limits were evaluated for maximum beam currents up to 10 μA .



Review Comments and Responses

None.

WNR Target 4 Radionuclide Inventory Calculation for Start of the 2002 Run Cycle

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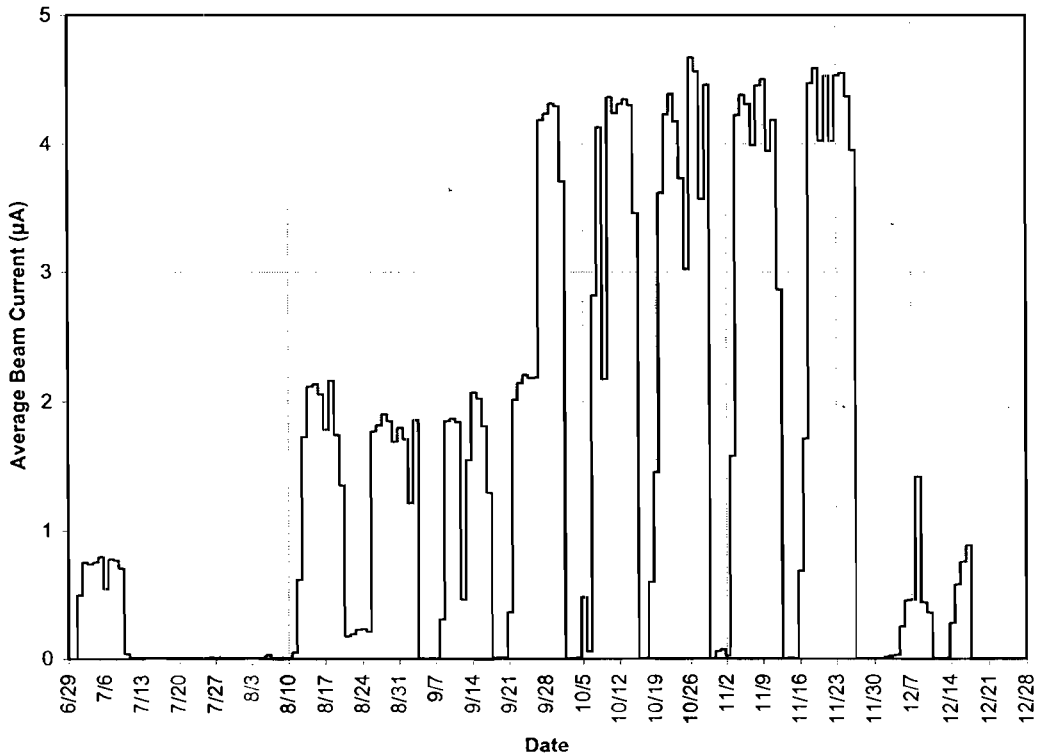
I. Introduction

This calculation satisfies the Justification for Continued Operation (JCO) commitment to evaluate the “new” target radionuclide inventory prior to the start of each run cycle [1]. The calculation was performed independent of past evaluations for the same purpose, and its results are consistent with the interim results for the 2001 run cycle [2]. Additionally, as required by LANSCE-3 routine operating procedure, an integrated beam current limit was calculated for the “new” target, assuming the 2001 run cycle’s maximum beam current of 5 μA [3]. LANSCE-3 has however suggested that they may need to raise the maximum beam current, so, integrated beam current limits were also evaluated for maximum currents up to 10 μA .

II. Operational History

The “new” target was installed during the 2001 outage and received beam during the 2001 run cycle. The “old” target was physically isolated from the beam line and the cooling system for the 2001 run cycle. It was then removed from the Weapons Neutron Research (WNR) Target 4 facility during the 2002 outage. LANSCE-3 provided beam delivery data for the 2001 run cycle based on the IRCM01 current monitor. The daily average beam current delivered to Target 4 was determined using this data, imposing the assumption that all beam delivered to WNR went to this target. A plot of the daily average beam current through the 2001 run cycle is presented in Figure 1.

Figure 1: Daily Average Beam Current Delivered to “New” Target During the 2001 Run Cycle



III. Radionuclide Inventory Calculation

The radionuclide inventory calculation was performed using the code systems MCNPX, Version 2.1.5, and CINDER90, Version c98f. MCNPX was used to calculate spallation product yields and the distribution of the neutron flux at energies below 25 MeV, both on a per micro-amp basis assuming an 800 MeV proton beam was incident on the target. The MCNPX input file is listed in Appendix A. CINDER90 was used for the time dependent evaluation of the inventory and integrated beam current limits based on the MCNPX results. CINDER90 input decks are listed in Appendices B, C, and D, respectively for the periods 6/30/01 to 9/17/01, 9/18/01 to 6/18/02, and 6/19/02 on. The first two decks provide the irradiation history by day as plotted in Figure 1 followed by the 2002 outage. For determination of an integrated beam current limit, the third deck provides continuous 5 μA beam delivery for 240 days beginning on 6/19/02. This deck was revised for the additional integrated current limit evaluations assuming continuous currents of 6, 7, 8, 9, and 10 μA .

Calculated Hazard Category 3 threshold ratios are plotted in Figure 2. The integrated beam currents resulting in threshold ratios of 0.95 assuming continuous delivery of maximum currents of 5 to 10 μA are listed in Table 1. These integrated beam current limits are for additional beam, assuming delivery begins on 6/19/02. Since the "new" target was installed, WNR has seen an integrated current of 5983 μA -hours, all of which was assumed to have been delivered to Target 4 for the present inventory calculation. If the maximum current is raised, the appropriate lower integrated current limit becomes applicable until a revised inventory calculation is completed. Table 2 lists activities of radionuclides identified as major contributors to the maximum Hazard Category 3 threshold ratios. During the 2001 run cycle the maximum threshold ratio of 0.37 was reached on 11/25. For comparison of this calculation with earlier evaluation results, the radionuclide activities on 9/16 are also listed.

Figure 2: Hazard Category 3 Threshold Ratios

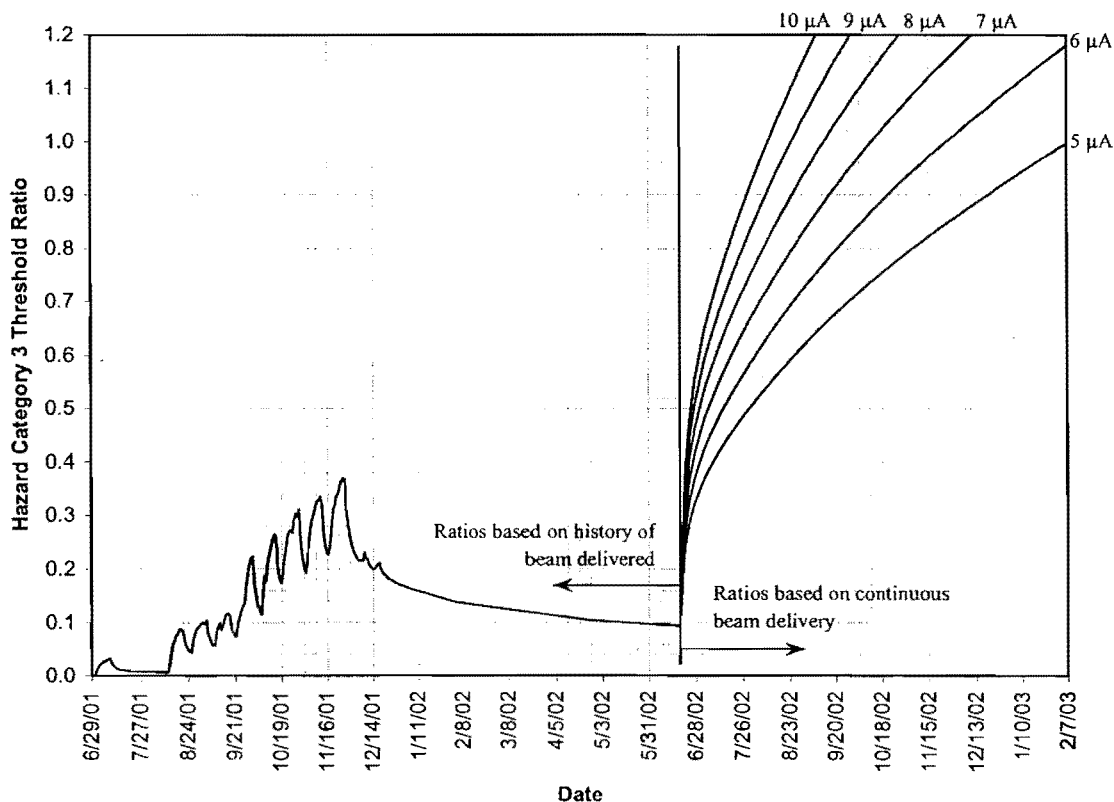


Table 1: Integrated Beam Current Limits

Maximum Beam Current (μA)	Integrated Beam Current Limit (μA-hours)
5	25088
6	20452
7	17136
8	14651
9	12686
10	11072

Table 2: Major Contributors to Maximum Hazard Category 3 Threshold Ratios

Inventory Date	Hazard Category 3 Threshold Ratio	Inventory Activities of Radionuclides that are Major Contributors to the Threshold Ratio (Curies)				
		I-125	Gd-148	Lu-170	Ta-176	Yb-166
9/16/01 (Ref. 2)	0.12	0.012	0.0013	6.0	8.1	4.5
9/16/01	0.12	0.011	0.0012	5.9	8.4	5.0
11/25/01	0.37	0.041	0.0055	15	21	12

IV. Conclusion

A Target 4 radionuclide inventory calculation was completed for irradiation of the “new” target during the 2001 run cycle. The maximum Hazard Category 3 threshold ratio was 0.37 on 11/25/01. Combined with the “old” target inventory as previously evaluated, the maximum threshold ratio was 0.98. The “old” target was removed during the 2002 outage, and going into the 2002 run cycle, the Hazard Category 3 threshold ratio for the “new” target is less than ten percent. Integrated beam current limits were determined for continued irradiation of the target. Assuming that a maximum beam current of 5 μA is established, the integrated beam current limit is 25,088 μA-hours. Selection of a higher maximum beam current will require a lower integrated beam current limit. Limits were evaluated for maximum beam currents up to 10 μA.

V. References

1. "Justification for Continued Operation for Los Alamos Neutron Science Center (LANSCE) Weapons Neutron Research (WNR) Facility – Target 4," Revision 0, August 30, 2001.
2. J. S. Bull, "WNR Target 4 Radionuclide Inventory Calculation, June 2001 – September 2001," CN-LANSCEFM-01-004.
3. "WNR Target-4 Nuclide Inventory Control," LANSCE-3-ROP-20, June 29, 2001.

Appendix A: MCNPX Input for Spallation Product and Flux Calculations

Target 4 Inventory Calculation

```

1 1 -19.3 -1 2 -3 $ active target
2 2 -1.00 1 -4 2 -3 $ active target cooling water
3 3 -7.92 4 -5 2 -3 $ steel jacket on active target
4 1 -19.3 -24 2 -3 $ stored target
5 0      24 -25 2 -3 $ stored target void cooling water region
6 3 -7.92 25 -26 2 -3 $ steel jacket on stored target
7 0      (26:-2:3) (5:-2:3) 6 -7 8 -9 10 -11 $ void space in target cell
8 4 -7.87 (-6:7:-8:9:-10:11) 12 -13 14 -15 16 -17 $ steel shld around target
9 5 -4.00 (-12:13:-14:15:-16:17) -27 $ steel concrete mix around steel shld
10 5 -4.00 27 18 -19 20 -21 22 -23 $ more of concrete mix in target cube
11 0      -18:19:-20:21:-22:23 $ external void
999 0 -999 u=1 $ ccc

```

```

1 cx 1.4986
2 px 0
3 px 7.493
4 cx 1.5748
5 cx 1.7335
6 px -91.44
7 px 91.44
8 py -60.96
9 py 60.96
10 pz -60.96
11 pz 60.96
12 px -121.92
13 px 274.32
14 py -91.44
15 py 91.44
16 pz -91.44
17 pz 91.44
18 px -609.6
19 px 609.6
20 py -609.6
21 py 609.6
22 pz -609.6
23 pz 609.6
24 c/x -30.48 0 1.4986
25 c/x -30.48 0 1.5748
26 c/x -30.48 0 1.7335
27 so 400
999 sq 25 100 0 0 0 0 -4 0 0 0

```

```

m1 74182.24 0.2652984 &
    74183.24 0.1433120 &
    74184.24 0.3067881 &
    74186.24 0.2846015 &
m2 1001.24 0.1118262 &
    1002.24 0.0000168 &
    8016.24 0.8881570 &
mt2 lwtr.02 hwtr.02
m3 26054.24 0.0402636 &
    26056.24 0.6314840 &
    26057.24 0.0145912 &
    26058.60 0.0019271 &
    24050.24 0.0087908 &
    24052.24 0.1693288 &
    24053.24 0.0191983 &
    24054.24 0.0047693 &
    28058.24 0.0609410 &
    28060.24 0.0234705 &
    28061.24 0.0010205 &
    28062.24 0.0032494 &

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```

28064.24 0.0008325 &
25055.60 0.0201332
m4 26054.24 0.0585000 &
26056.24 0.9175000 &
26057.24 0.0212000 &
26058.60 0.0028000
m5 1001.24 0.0069990 &
1002.24 0.0000011 &
6000.24 0.0009000 &
8016.24 0.2109000 &
11023.60 0.0045000 &
12000.60 0.0009000 &
13027.24 0.0120000 &
14028.24 0.0967493 &
14029.24 0.0048988 &
14030.24 0.0032519 &
16000.60 0.0006000 &
19000.60 0.0030000 &
20000.60 0.0428000 &
26054.24 0.0358313 &
26056.24 0.5619688 &
26057.24 0.0129850 &
26058.60 0.0017150
mode n h / d t s a
imp:n,h,/,d,t,s,a 1 6r .25 .0625 .015625 0 1
sdef par 9 erg 800 wgt 6.242+12 dir 1 vec 0 0 1 x d1 y d2 z 0 ccc 999 tr 1
sp1 -41 .470964 0
sp2 -41 .2358482 0
tr1 -2 0 0 0 1 0 0 0 1 1 0 0
phys:h 810 j 0
phys:n 810 3j 25
f4:n 1
e4 1.-11 5.-9 1.-8 1.5-8 2.-8 2.5-8 3.-8 3.5-8 4.2-8 5.-8 5.8-8 6.7-8 &
8.-8 1.-7 1.52-7 2.51-7 4.14-7 6.83-7 1.125-6 1.855-6 3.059-6 5.043-6 &
8.315-6 1.371-5 2.26-5 3.727-5 6.144-5 1.013-4 1.67-4 2.754-4 4.54-4 &
7.485-4 1.234-3 2.035-3 2.404-3 2.840-3 3.355-3 5.531-3 9.119-3 1.503-2 &
1.989-2 2.554-2 4.087-2 6.738-2 1.111-1 1.832-1 3.02-1 3.887-1 4.979-1 &
6.39279-1 8.2085-1 1.10803+0 1.35335+0 1.73774+0 2.2313+0 2.86505+0 &
3.67879+0 4.96585+0 6.065+0 1.+1 1.49182+1 1.69046+1 2.+1 2.5+1
histp 1
prdmp j -180
nps 4+6

```


Appendix B: CINDER90 Input for Inventory Calculations from 6/30/01 to 9/17/01

WNR Target 4 Radionuclide Inventory

5.28661E+01,1.,1.E-4,1.E-10,,,,,2,-1,2,1/

New Target

For TQ3 ratios and integrated beam current limit from 6-30-01 to 9-17-01

Calculated with CINDER'90 (c98f) and 1998 Library (LibB2-Q) of 3400 Nuclides

cell 1

ml

1 0.497

1 'd'

1 0.754

1 'd'

1 0.737

1 'd'

1 0.754

1 'd'

1 0.794

1 'd'

1 0.549

1 'd'

1 0.775

1 'd'

1 0.766

1 'd'

1 0.706

1 'd'

1 0.037

1 'd'

1 0.006

1 'd'

1 0.006

1 'd'

1 0.006

1 'd'

1 0.006

1 'd'

1 0.011

1 'd'

1 0.012

1 'd'

1 0.010

1 'd'

1 0.009

1 'd'

1 0.014

1 'd'

1 0.011

1 'd'

1 0.011

1 'd'

1 0.009

1 'd'

1 0.009

1 'd'

1 0.007

1 'd'

1 0.007

1 'd'

1 0.010

1 'd'

1 0.008

1 'd'

1 0.015

1 'd'

1 0.013
1 'd'
1 0.015
1 'd'
1 0.010
1 'd'
1 0.014
1 'd'
1 0.015
1 'd'
1 0.014
1 'd'
1 0.010
1 'd'
1 0.013
1 'd'
1 0.030
1 'd'
1 0.004
1 'd'
1 0.004
1 'd'
1 0.006
1 'd'
1 0.004
1 'd'
1 0.049
1 'd'
1 0.615
1 'd'
1 1.727
1 'd'
1 2.117
1 'd'
1 2.138
1 'd'
1 2.059
1 'd'
1 1.785
1 'd'
1 2.161
1 'd'
1 1.745
1 'd'
1 1.355
1 'd'
1 0.174
1 'd'
1 0.194
1 'd'
1 0.229
1 'd'
1 0.233
1 'd'
1 0.212
1 'd'
1 1.772
1 'd'
1 1.818
1 'd'
1 1.903
1 'd'
1 1.851
1 'd'
1 1.692

1 'd'
1 1.797
1 'd'
1 1.712
1 'd'
1 1.216
1 'd'
1 1.858
1 'd'
1 0.004
1 'd'
1 0.001
1 'd'
1 0.007
1 'd'
1 0.004
1 'd'
1 0.307
1 'd'
1 1.848
1 'd'
1 1.869
1 'd'
1 1.841
1 'd'
1 0.462
1 'd'
1 1.550
1 'd'
1 2.070
1 'd'
1 2.024
1 'd'
1 1.811
1 'd'
1 1.292
1 'd'

Appendix C: CINDER90 Input for Inventory Calculations from 9/18/01 to 6/18/02

WNR Target 4 Radionuclide Inventory

5.28661E+01,1.,1.E-4,1.E-10,,,,,,,,,2,79,2,1/

New Target

For TQ3 ratios and integrated beam current limit from 9-18-01 to 6-18-02

Calculated with CINDER'90 (c98f) and 1998 Library (LibB2-Q) of 3400 Nuclides

cell 1

m1

1 0.009
 1 'd'
 1 0.009
 1 'd'
 1 0.009
 1 'd'
 1 0.363
 1 'd'
 1 2.014
 1 'd'
 1 2.144
 1 'd'
 1 2.207
 1 'd'
 1 2.181
 1 'd'
 1 2.187
 1 'd'
 1 4.183
 1 'd'
 1 4.234
 1 'd'
 1 4.315
 1 'd'
 1 4.294
 1 'd'
 1 3.708
 1 'd'
 1 0.003
 1 'd'
 1 0.003
 1 'd'
 1 0.007
 1 'd'
 1 0.481
 1 'd'
 1 0.056
 1 'd'
 1 2.817
 1 'd'
 1 4.129
 1 'd'
 1 2.174
 1 'd'
 1 4.362
 1 'd'
 1 4.238
 1 'd'
 1 4.312
 1 'd'
 1 4.345
 1 'd'
 1 4.301
 1 'd'
 1 3.463
 1 'd'

1 0.006
1 'd'
1 0.008
1 'd'
1 0.597
1 'd'
1 1.456
1 'd'
1 3.620
1 'd'
1 4.228
1 'd'
1 4.388
1 'd'
1 4.173
1 'd'
1 3.734
1 'd'
1 3.021
1 'd'
1 4.670
1 'd'
1 4.562
1 'd'
1 3.573
1 'd'
1 4.458
1 'd'
1 0.002
1 'd'
1 0.057
1 'd'
1 0.074
1 'd'
1 0.023
1 'd'
1 1.581
1 'd'
1 4.221
1 'd'
1 4.378
1 'd'
1 4.307
1 'd'
1 3.985
1 'd'
1 4.451
1 'd'
1 4.500
1 'd'
1 3.944
1 'd'
1 4.183
1 'd'
1 2.862
1 'd'
1 0.002
1 'd'
1 0.008
1 'd'
1 0.005
1 'd'
1 0.686
1 'd'
1 1.715

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1 4.471
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1 4.589
1 'd'
1 4.022
1 'd'
1 4.527
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1 4.019
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1 4.529
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1 4.551
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1 0.008
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1 0.0
9 'd'
1 0.0
27 'd'
1 0.0
81 'd'
1 0.0
55 'd'

Appendix D: CINDER90 Input for Inventory Calculations for 2002 Run Cycle

WNR Target 4 Radionuclide Inventory
5.28661E+01,1.,1.E-4,1.E-10,,,,,,,,,2,104,2,1/
New Target
For TQ3 ratios and integrated beam current limit from 6-19-02 to 1-25-05
Calculated with CINDER'90 (c98f) and 1998 Library (LibB2-Q) of 3400 Nuclides
cell 1
ml
1 5.000
3 'd'
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