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August 23, 2013

Mr. Alexander Adams
U. S. Nuclear Regulatory Commission
Research and Test Reactors Branch A
Office of Nuclear Reactor Regulation
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Reference: Oregon State University TRIGA Reactor (OSTR)
Docket No. 50-243, License No. R-106
License Ammendment Letter dated April 13, 2012
Affidavit Letter dated April 13, 2012
USNRC RAI Letter dated April 22, 2013

Subject: Answers to Request for Additional Inforamtion request by USNRC with respect to a license amendment application for the purpose of demonstrating ^{99}Mo production capability in the OSTR

Mr. Adams:

This letter serves as a reply to the Request for Additional Information (RAI) letter dated April 22, 2013, pertaining to a license amendment application for the purpose of allowing a fueled experiment. Consistent with the affidafid letter of April 13, 2012, some of the information in the answers to the RAI letter will be proprietary in nature and we request that the information be withheld from public disclosure. There are two enclosures with this letter. Enclosure 1 is a proprietary version of the answers to the RAI letter. Information which is **BOLDED** denotes proprietary information. Enclosure 2 is a public version of the answers to the RAI letter. Information which is redacted is denoted in [....]. I hereby affirm, state, and declare under penalty of perjury that the foregoing is true and correct.

Executed on: 8/23/13

If you have any questions, please do not hesitate to contact me.

Sincerely,

Steve Reese
Director

cc: ✓Document Control, NRC
Craig Bassett, NRC w/o attachements
Rick Spinrad, OSU
Rich Holdren, OSU
Andy Klein, OSU w/o attachements

A020
NRR

By letter dated April 22, 2013, the USNRC requested the following additional information. Enclosure 1 is a non-public version of the request for additional information. Information which is **BOLDED** denotes proprietary information. Enclosure 2 is a public version of the request for additional information. Information which is redacted is denoted in **[ ]**.

1. There appears to be inconsistencies between the table of contents for Appendix A of the safety analysis report (SAR) and the text of the SAR and also within the SAR. For example, it appears that the reference to Table 4 at the top of page 22 should be Table 5. Please review the SAR and revise as needed.

   The page numbers listed in the report provided as Appendix A correspond to the page numbers in that report. However, when the files were merged just prior to submission, the word processing program included page numbers that corresponded with the license amendment application into the report found in Appendix A.

   This reference to Table 4 identified was a typographical error. The reference should be to Table 5, not Table 4.

2. Several references in the text of the SAR appear to be missing. For example, a reference is missing at the bottom of page 55 and the top of page 56 of the SAR. Please revise as needed.

   This was a typographical error. The "[reference needed]" quoted on the pages 55 and 56 should have been (respectfully):

   [....].

   [....]

   The "[reference DWG]" in the middle of page 56 should have read, "[see Appendix B]".

3. Section II and V.VII. Please provide additional detail on the quality assurance measures applied to the fabrication of targets including testing of targets to help ensure they meet design criteria.

   Direct communication between OSU and the party responsible for manufacturing the target(s) has been maintained through the reactor component design process and conduct of the safety analysis. This communication ensures all applicable technical and functional requirements from the reactor safety bases are carried forward through the design and fabrication of the target(s). OSU will ensure that all fabrication drawings, component specifications, and other baseline configuration documentation of relevance are consistent with this analysis.

   The targets will be manufactured under a NQA-1-2008 Quality Assurance program with 2009 Addenda held by the party responsible for manufacture of the targets. At a minimum, the following information or functions performed during the process of manufacturing the targets:

   - Minimum criteria for weld inspection shall include a visual inspection, liquid penetrant test and helium leak test.

- Weld and welder qualifications shall conform to applicable ASME Boiler and Pressure Vessel Code or equivalent AWS standard(s).
- Appropriate certifications shall be acquired and maintained on file in accordance with NQA-1-2008 document control requirements which include, but are not limited to material testing reports (MTRs), shop fabrication travelers, inspection documents, inspector certifications, and welder and fabricator certifications.
- Reports, certifications and procedures shall be retained for a period of at least three (3) years following irradiation.

4. Section III, page 14. The SAR discusses the k-effective of targets stored in the in-tank racks. Do the values given reflect storage with the maximum allowed amount of fuel elements also in the storage racks? If not, what is the k-effective of the most limiting configuration of targets and fuel?

   Analysis of a mixture of targets and fuel has not been performed. The maximum possible k_{eff} value of LEU fuel in the in-tank storage racks was determined during safety analysis calculations. The analysis assumed the 2x10 fuel storage rack contained 20 copies of the most reactive fuel element at its most reactive point in core life. This configuration produces a k_{eff} value of 0.71492 ± 0.00049. As stated in the license amendment, the maximum k_{eff} of three targets stored in one of the in-tank storage rack is 0.46906 ± 0.00041. The proposed technical specification LCO T3, which would apply any time a target is in the reactor tank and not in the core lattice, prohibits storing any other items in a storage rack while the rack contains one or more targets. This amendment is specifically written to allow use of no more than three targets, so the value of 0.46906 represents the effective upper limit of any permissible configuration involving targets in a storage rack.

5. Section V.II. Please provide complete details as to the derivation of the source term [..........................] from the fuel in the target.

   Because data on the [..........................] at low temperature and burn up appears to be unavailable at temperatures [..........................], an alternate approach is provided here. Instead of deriving the [..........................], the [..........................] is determined directly from documents published by General Atomics related to [..........................]. A summary of the release fraction mechanics can be found in [..........................]. This reference does provide data on [..........................] but not in a configuration similar to that found in the targets. As an example, the "[..........................]" listed in Table 4-14 are actually [..........................] made of [..........................], not a [..........................] themselves.

   The [..........................] in a [..........................] configuration can be inferred from Table 1 and Figure 2 of [..........................] (Ref. 2). Table 1 from [..........................] provides data on several forms of [..........................] configurations for ^{85m}Kr at [..........................] °C. (Note that the value of [..........................] in Table 1 for "[..........................] originates from the data in Figure 2 of [..........................].) The configuration which most closely approximates that proposed for the targets is the "[..........................]" with a listed

[............................]. From this same table, the ratio of [............................] to that of the "[............................] °C is 0.04/0.002=20.

The data in Figure 2 of [............................] shows the exponential decrease of [............................] for [............................]. Using the same ratio of [............................]" of 20 and applying it at 200°C for temperature, the [............................] can be estimated to be 0.002/20=0.0001.

This approach assumes that the ratio remains the same as a function of temperature. References to [............................] values presented in [............................] as well as references presented in the license amendment addressing this issue all suggest that the data follows this negative power function. As such, it is likely that this assumption is applicable. It is interesting to note that the value calculated here is consistent with the value of [............................] derived from the extrapolated [............................] presented in the license amendment.

Using the methodology presented in the license amendment and consistent with that found in the SAR, the value of [............................] derived from the [............................] is replaced with 0.0001 in Table 5-1 below. All other values and methodology remaining the same, the occupational doses and doses to the general public are provided in Tables 5-2 through 5-5 below.

Table 5-1 – Airborne Radioactive Source Term (Note: replaces Table 5 in the license amendment)

Isotope	Isotope Half-life (s)	Isotope Decay Constant (1/s)	U-235 Fission Product Yield	Target Activity (mCi)	[...]	No Water Reactor Bay Air Activity (mCi)	Water Reactor Bay Air Activity (mCi)
Br-82	127080	5.45E-06	6.10E-07	[....]	[....]	0.00	0.00
Br-83	8640	8.02E-05	5.38E-03	[....]	[....]	1.34	0.07
Br-84m	360	1.93E-03	3.18E-04	[....]	[....]	0.08	0.00
Br-84	1908	3.63E-04	1.00E-02	[....]	[....]	2.51	0.13
Br-85	172.2	4.03E-03	1.26E-02	[....]	[....]	3.16	0.16
Br-86	55.5	1.25E-02	1.82E-02	[....]	[....]	5.45	0.23
Br-87	55.9	1.24E-02	2.02E-02	[....]	[....]	5.04	0.25
I-131	692928	1.00E-06	2.88E-02	[....]	[....]	7.21	0.36
I-132	8208	8.44E-05	4.30E-02	[....]	[....]	10.74	0.54
I-133	74880	9.26E-06	6.70E-02	[....]	[....]	16.74	0.84
I-134	3156	2.20E-04	7.74E-02	[....]	[....]	19.33	0.97
I-135	23652	2.93E-05	6.29E-02	[....]	[....]	15.72	0.79
I-136	83.4	8.31E-03	2.47E-02	[....]	[....]	6.18	0.31
Kr-83m	6696	1.04E-04	5.38E-03	[....]	[....]	5.38	5.38
Kr-85m	16128	4.30E-05	1.26E-02	[....]	[....]	12.62	12.62
Kr-85	3.39E+08	2.04E-09	2.74E-03	[....]	[....]	0.17	0.17
Kr-87	4572	1.52E-04	2.51E-02	[....]	[....]	25.14	25.14
Kr-88	10224	6.78E-05	3.57E-02	[....]	[....]	35.67	35.67
Kr-89	189	3.67E-03	4.61E-02	[....]	[....]	46.10	46.10
Xe-131m	1028160	6.74E-07	3.17E-04	[....]	[....]	0.32	0.32
Xe-133m	189216	3.66E-06	1.95E-03	[....]	[....]	1.95	1.95
Xe-133	452736	1.53E-06	6.70E-02	[....]	[....]	67.00	67.00
Xe-135m	918	7.55E-04	1.21E-02	[....]	[....]	12.13	12.13
Xe-135	32760	2.12E-05	6.53E-02	[....]	[....]	65.29	65.29
Xe-137	229.2	3.02E-03	6.11E-02	[....]	[....]	61.09	61.09
Xe-138	846	8.19E-04	6.37E-02	[....]	[....]	63.71	63.71

Table 5-2 – Occupational Radiation Doses in the Reactor Room Following a Single Target Failure at End of Bombardment (Note: replaces Table 7 from license amendment)

Scenario	Release Environment	Occupancy (minutes)	$CDE_{Thyroid}$ + $DDE_{Thyroid}$ (mrem)	TEDE (mrem)
A	Water	2	1	<1
A	Water	5	1	<1
A	Air	2	17	1
A	Air	5	17	1
B	Water	2	7	2
B	Water	5	15	2
B	Air	2	112	5
B	Air	5	253	12
C	Water	2	7	2
C	Water	5	18	4
C	Air	2	120	6
C	Air	5	299	14

Table 5-3 –Radiation Doses to Members of the General Public Following a Single Target Failure in Air at End of Bombardment – Scenario A (Note: replaces Table 8 in the license amendment)

Distance (m)	With Primary Water $CDE_{Thyroid}$ + $DDE_{Thyroid}$ (mrem)	With Primary Water TEDE (mrem)	No Primary Water $CDE_{Thyroid}$ + $DDE_{Thyroid}$ (mrem)	No Primary Water TEDE (mrem)
10	14	3	230	11
50	7	1	105	5
100	2	<1	36	2
150	1	<1	15	1
200	1	<1	9	<1
250	<1	<1	6	<1
267	<1	<1	5	<1

Table 5-4 –Radiation Doses to Members of the General Public Following a Single Target Failure in Air at End of Bombardment – Scenario B (Note: replaces Table 9 in the license amendment)

Distance (m)	With Primary Water $CDE_{Thyroid} + DDE_{Thyroid}$ (mrem)	With Primary Water TEDE (mrem)	No Primary Water $CDE_{Thyroid} + DDE_{Thyroid}$ (mrem)	No Primary Water TEDE (mrem)
10	13	2	228	10
50	6	1	104	4
100	2	<1	36	2
150	1	<1	15	1
200	1	<1	9	<1
250	<1	<1	6	<1
267	<1	<1	5	<1

Table 5-5 –Radiation Doses to Members of the General Public Following a Single Target Failure in Air at End of Bombardment – Scenario A (Note: replaces Table 10 in the license amendment)

Distance (m)	With Primary Water $CDE_{Thyroid} + DDE_{Thyroid}$ (mrem)	With Primary Water TEDE (mrem)	No Primary Water $CDE_{Thyroid} + DDE_{Thyroid}$ (mrem)	No Primary Water TEDE (mrem)
10	8	<1	165	5
50	4	<1	75	2
100	1	<1	26	1
150	1	<1	11	<1
200	<1	<1	7	<1
250	<1	<1	4	<1
267	<1	<1	4	<1

Both the occupation doses and doses to the general public are lower using this approach over that predicted by the [....]to calculate an [....]using an extrapolated [....]. While the value for [....]presented is higher in some cases and lower for others, it is the value for ^{131}I that is largely responsible for the doses. In this case the value of [....]is lower for ^{131}I and therefore the resulting doses are lower as well.

References:

[....]
[....]

6. Section V.IV. Please evaluate the accident where there is a rapid insertion of reactivity into the reactor similar to your evaluation for your license renewal.

A calculation evaluating an accident with the targets in the core where there is a rapid insertion of reactivity into the reactor similar to that performed for the license renewal has been thoroughly investigated and found to exceed the limitations of the computational tools used as a part of this license amendment. The method used to perform the calculation involved the use of RELAP5-3D. The pulse transient simulated by RELAP5-3D implements the point reactor kinetics model that has been built into the code. By its very nature, a point reactor kinetics model must assume and use average core parameters. Therefore, this methodology does not allow or account for the input of separate fuel parameters (i.e, volumetric heat capacity, effective delayed neutron fraction over the mean neutron generation, and the prompt fuel temperature coefficient) for more than one material.

An alternate approach is to assume that a pulse will result in a cladding breach of all the targets simultaneously. By multiplying the values calculated in RAI question 5 above by three to represent a breech from all three targets, the unrestricted area doses are still below the annual limit for members of the general public found in 10 CFR 20.

7. Section V.VI. Please provide an analysis of the loss or reduction of flow to the [....] target.

The target is of [....]. Because of this geometrical configuration, it is conceivable that the [....]element may become blocked during full power operation (integral reactor power at 1.1 MW_{th}) without reactor operator knowledge. The following results present the characteristics of the fluid adjacent to the target, in the event that the [....]were blocked (no flow is permitted to flow through the [....]) while the element operates at [....]kW.

This case was modeled in RELAP5-3D by forcing the [....]wall boundary condition to be adiabatic thereby requiring all heat to numerically dissipate through the [....]. Furthermore, all thermo-physical properties that have been included in results presented as a part of questions 20, 21, and 22, are consistent with the results presented herein for a flow blockage case. Note from Table 7-1, that the flow rate in the [....]is not zero; this is because of entrained fluid through [....]must move to satisfy [....]. Figure 7-1 through 7-3 present the steady state results of the target at [....]kW with the [....]blocked of heat removal capability.

Table 7-1: [....]Results for the target ([....]kW)

Parameter	[....]	[....]
Flow rate for hottest rod [kg/s]	[....]	[....]
Maximum flow velocity [m/s]	[....]	[....]
Maximum wall heat flux [kW/m^2]	[....]	[....]
Maximum fuel centerline temperature [°C]	[....]	
Maximum clad temperature [°C]	[....]	[....]
Exit clad temperature [°C]	[....]	[....]
Exit bulk coolant temperature [°C]	[....]	[....]
MDNBR [Groeneveld 2006, Bernath]	NA	9.638, 5.890

[....]

Figure 7-1: Axial temperature distribution at [....]kW with [....] channel blockage

[....]

Figure 7-2: Radial temperature distribution at [....]kW with [....] channel blockage

[....]

Figure 7-3: Axial DNBR distribution at [....]kW with [....] channel blockage

8. Section V.IX. Briefly describe why the severity of a loss of electric power event is not increased by the irradiation of the targets.

   Loss of electric power is a benign condition at the Oregon State University TRIGA Reactor (OSTR). On loss of electric power, the operator completes a reactor shutdown which includes securing cooling and circulation, if not already lost due to the power outage. Core decay heat is transferred to the large tank of primary water. Experience has shown that the tank demonstrates a slow net loss of temperature, due to ambient losses, which are greater than decay heat levels in the core. Decay heat produced in an end-of-life fuel element which has been operated for many years will be much greater than decay heat produced in a target which has been irradiated for 6.5 full power days. Uranium consumption in an end-of-life fuel element is typically tens of grams. Uranium consumption in a target irradiated for 6.5 days is less than [....] gram. Decay heat production is governed by the fission product burden and also affected by operating tempo. Under any foreseeable irradiation scenario, the decay heat production of a target will be much lower than the decay heat production of an end-of-life fuel element, and is therefore bounded by the safety analyses performed as a part of the SAR which consider loss of power at a fuel element's end-of-life.

9. Section V.X. Briefly describe why the severity of external events is not increased by the irradiation of the targets.

   External events occur independently of OSTR status. The frequency or intensity of such events is not affected by core loading. Hurricanes, tornadoes and floods are virtually nonexistent in the Corvallis area and seismic activity is relatively low compared to other areas of the Pacific Northwest, as illustrated in the SAR. Furthermore, the effect an external event would have on the targets would be a loss of cladding integrity. This is covered by the accident analyzed and in RAI question 6 above.

10. Section V.XI. Briefly describe why the severity of mishandling or malfunction of equipment is not increased by the irradiation of the targets.

    No credible accident initiating events were identified for this accident class, but the OSTR SAR discusses malfunction of the reactor control system, the reactor confinement system and rapid leaks. As stated in the license amendment, addition of no more than three targets will result in no significant change in core parameters or operating characteristics, so the behavior of the control system will not be impacted.

    Operation of the confinement system is not required to mitigate releases from a failed target as discussed in the response to RAI question 5 above.

The presence of targets in the core does not change the likelihood or nature of a loss of coolant accident, since such an event will be triggered by ex-tank circumstances and the worst accident, addressed in the accident analysis and in RAI question 5 above are shown to be acceptable from a public health and safety perspective.

11. Figure 1 (in the SAR) and Figure 8 (in Appendix A) list values for the cladding thickness that do not match the value in Table 1. The cladding thickness is also displayed in Appendix B, Section B-B (page 93) of the license amendment. Please revise as needed.

    The values in Figure 1 and Figure 8 (in Appendix A) for the "[....] CLADDING (TUBE) THICKNESS 1.60 mm" is incorrect. It should read "[....]CLADDING (TUBE) THICKNESS 3.20 mm".

12. Section VI, LCO T4. Please revise this TS to remove proprietary information. For example, the specific fuel form can be removed from the proposed TS on target enrichment.

    Please replace LCO T4 with the following:

    - LCO T4, Target Fabrication Requirements.

      Applicability: This specification applies to any target that will be placed in the reactor tank.
      Objective: To assure that targets placed in the core may be used with a high degree of reliability with respect to their physical and nuclear properties.
      Specification:
      a. The maximum enrichment of uranium in each target shall not exceed 19.75%.
      b. The maximum mass of uranium in a target shall not result in a dose to a member of the general public in excess of 100 mrem from an accident involving a single target.
      c. Cladding: aluminum, nominal thickness 0.32 cm.

      Basis:
      a. Targets must be fabricated with LEU (i.e., less than or equal to 19.75% enriched in ^{235}U). An enrichment of 20% was assumed for the neutronic and the thermal hydraulic analysis for the purpose of bounding the calculations.
      b. The dose to the general public from the maximum hypothetical accident (MHA) is a function of many variables. Provided all other variables remain constant, the predicted dose should be directly proportional to the mass of uranium in the target. Analysis has shown that the maximum dose to a member of the general public will not exceed 100 mrem given the assumptions made in the calculation of the MHA. Therefore, the mass of uranium in each target is limited by the parameters of the analysis and the dose performance criteria.

c. Cladding of this type provides adequate structural integrity while minimizing parasitic neutron absorption.

13. Section VI. Because of the additional complexity of fission in fueled experiments as compared to activation experiments, it is standard to have a TS that limits the fission product inventory in the target. For example, the TS could place an upper limit on significant fission products such as iodine and strontium. Also, it is common to have a TS requirement to prohibit boiling on the surface of the experiment. Please propose and justify such TSs or explain why such TSs are not needed.

    The nature of this target is sufficiently unique that a specific TS for this target is more appropriate than a generic TS that covers all fueled experiments. The license amendment for these targets is very strictly scoped due to the amount and nature of the fuel. Specifically, the methodology for the source term isotopic production is unlikely to be applicable to any other fueled experiment. Given these factors, a TS for other fueled experiments is not warranted at this time.

14. Section VII. Please revise your proposed license condition to remove proprietary information. For example, the form of the uranium can be stated as experimental Mo-99 production targets.

    Please change changing the proposed license condition 2.b.2.f to:

    > To receive, possess, use, but not separate, up to 1.0 kilograms of contained uranium-235 enriched to less than 20 percent in the form of Mo-99 production targets.

15. Section 2.1, page 55. Please verify that the targets contain low-enriched uranium. Enrichment of 20 percent as stated in the first sentence of this section is considered high-enriched.

    Both the neutronics and thermal hydraulic analyses assumed 20% enrichment for the purpose of bounding the calculations. The proposed LCO T4 is in error. The proposed LCO T4.a and its associated bases should have read:

    LCO T4.a: "The maximum enrichment of uranium in target shall be less than 20%."

    Basis for LCO T4.a: "Targets must be fabricated with LEU. An enrichment of 20% was assumed for the neutronic and the thermal hydraulic analyses for the purpose of performing conservative and bounding analyses."

16. Table 1 on page 11 and Table 6 on page 57 each lists [....], which differs from the text on page 56 which references [....]. Further, the calculations using [....]are based upon [....]. Please discuss and revise as needed.

    This is a typographical error. Table 1 on page 11 and Table 6 on page 57 each should list the correct [....]which was employed during all safety analysis calculations.

17. There appears to be a missing decimal for the [....]on page 56. Please discuss and revise as needed.

    This was a typographical error. The value should be [....]g/cm^3.

18. The fuel volume is presented both as [....]cm3 (page 56) and [....]cm3 (page 60), using the same data. Please discuss and revise as needed.

    The difference occurred due to rounding the values for the surfaces in the calculation for the thermal conductivity of the [....]. The difference is not considered significant with respect to the fidelity of the models used. Furthermore, the net effect is a reduced thermal conductivity value producing a slightly (insignificantly) more conservative value.

19. Page 56, last sentence of first paragraph – the text uses “multiplying.” Should this be “divided?” Please discuss and revise as needed.

    The text description of the action to acquire volume occupied by the fuel was incorrectly written. However, a confirmation of the computed value demonstrated correct calculation. The correct textual articulation of the last sentence of the first paragraph on page 56 should read as follows:

    “The total volume that the [....]*fuel occupies may be calculated by dividing the total controlled mass by the* [....]*, producing an occupied fuel volume of* [....]*cm^3.”*

20. Equation 6 on Page 60 is the effective mass averaged thermal conductivity for the fuel meat. However, it appears that this equation does not reduce to equation 7 and the plotted value of keff in Figure 15 is incorrect. What appears to be displayed is an average of the conductivity values, but it has not been mass-averaged. Please discuss and revise as needed.

    After several independent reviews of the ‘effective mass averaged thermal conductivity’ (k_{eff}) for the fuel meat it was determined that the originally articulated values presented (both in textual and tabular form) were incorrectly applied to the mass averaging relation. As a result, the temperature dependent effective mass averaged thermal conductivity used throughout the thermal hydraulics portion of the study was incorrect. Figure 20-1 presented below, correctly applies the mass averaging method to acquire k_{eff} for the fuel meat region. This value was independently confirmed. Note that k_{eff} of the fuel meat region is nearly analogous to that of the [....] (even with a [....]). This is due to the significant relative difference in material density of the [....] within the fuel meat region.

[....]

Figure 20-1: Thermal conductivity of [....]

The relation presented in equation (7) of the license amendment is incorrect as written and shall be replaced with:

[....] **(7)**

21. Equation 9 on Page 62 is the effective mass averaged volumetric heat capacity of the fuel meat. However, it appears that this equation does not reduce to equation 10 and the plotted value of Cp in Figure 16 is incorrect. What appears to be displayed is an average of the heat capacity values, but it has not been mass-averaged. Please discuss and revise as needed.

After several independent reviews of the 'effective mass averaged volumetric heat capacity' ($\rho C_{p,eff}$) for the fuel meat it was determined that the originally articulated values presented (both in textual and tabular form) were incorrectly applied to the mass averaging relation. As a result, the temperature dependent effective mass averaged volumetric heat capacity used throughout the thermal hydraulics portion of the study was incorrect. Figure 21-1, presented below, correctly applies the mass averaging method to acquire $\rho C_{p,eff}$ for the fuel meat region. This value was independently confirmed. Note that $\rho C_{p,eff}$ of the fuel meat region is nearly analogous to that of the [....]). This is due to the significant relative difference in material density of [....]within the fuel meat region.

[....]

Figure 21-1: Volumetric heat capacity [....])

The relation presented in equation (10) of the license amendment is incorrect as written and shall be replaced with:

[....] **(10)**

22. If you conclude that the thermal conductivity and heat capacity have been incorrectly formulated, please provide a revised thermal hydraulic analysis or justify why the existing analysis is still valid.

The responses to questions 20 and 21 acknowledge that the formulae developed for effective mass averaged thermal conductivity and effective mass averaged volumetric heat capacity within the fuel meat region of the target were incorrect in both their textual description and application. The correct thermal conductivity within the fuel meat region is approximately three times greater than that which was applied during the original analysis. This increase in thermal conductivity will inherently result in lower maximum fuel temperature values during steady state operation; therefore the original analysis yielded conservative results. However, in order to maintain transparency and provide comprehensive disclosure regarding the state of the target, all steady state results have been computed with the corrected thermo-physical property values. Each figure and table identified below provides updated, corrected values for the target for its corresponding figure/table in the license amendment.

Table 22-1: Steady State Results for the target ([....]kW)

Parameter	[....]	[....]
Flow rate for hottest rod [kg/s]	[....]	[....]
Maximum flow velocity [m/s]	[....]	[....]
Maximum wall heat flux [kW/m^2]	[....]	[....]
Maximum fuel centerline temperature [°C]	[....]	
Maximum clad temperature [°C]	[....]	[....]
Exit clad temperature [°C]	[....]	[....]
Exit bulk coolant temperature [°C]	[....]	[....]
MDNBR [Groeneveld 2006, Bernath]	17.449, 11.822	16.049, 9.479

[....]

Figure 22-1: Axial temperature distribution at [....]kW

[....]

Figure 22-2: Radial temperature distribution at maximum axial fuel temperature at [....]kW

[....]

Figure 22-3: Target Axial DNBR distribution at [....]kW

[....]

Figure 12-4: Target channel properties

[....]

Figure 22-5: Target maximum temperatures

[....]

Figure 22-6: Target MDNBR

A Loss of Coolant Analysis (LOCA) analysis was performed in a different manner than that presented in the original license amendment application in order to more accurately represent the conditions under which the target will exposed. In this LOCA analysis, a decay power profile, generated from SCALE was used as the input temporal power for the target. Figure 22-7 presents the decay power profile which was employed from ANSI/ANS-5.4 2005 standard in the original license amendment as well as the decay power profile output by SCALE. Note that these power profiles differ from one another. The power profile tabulated from ANSI/ANS-5.4 2005 assumes that the reactor (and target) have been operating for an effective infinite period of time before the SCRAM and that all fissile isotopes contribute to the decay power profile with 100 percent of their potential. This creates isotopic ratios and activity magnitudes very different from that of an irradiation of 6.5 days. To account for this difference, a SCALE simulation was run with the appropriate cycle length (i.e., 6.5 effective full power days), which resulted in a reduced decay power profile as compared to that produced from the ANSI/ANS-5.4 2005 standard.

[....]

Figure 22-7: Decay power of ANSI-15.1 and SCALE output

Figure 22-8 presents the temperature transient of the Mo-Element after a SCRAM event. Two scenarios are presented in Figure 22-8. One scenario assumes that the element is exposed to air at the instant that a SCRAM occurs (depicted in the legend as "0 hr After SCRAM"). The second scenario assumes that the target is exposed to air one hour after a SCRAM occurs (depicted in the legend as "1 hr after SCRAM"). The values presented in these temperature transients are tabulated from the location within the element which results in the maximum temperature at each discrete time. Of these two scenarios, the maximum target temperature for instantaneous exposure (0 hr After SCRAM) was found to be 531°C at a time of 3000 seconds (or 0.833 hr) after air exposure. The second scenario (assuming a wait period of 1 hr after SCRAM) quantifies the maximum temperature in the target to be 317°C at a time of 4000 seconds (or 1.111 hr) after air exposure. This implies that the target never reaches the melting point of aluminum post irradiation during a LOCA event. This peak temperature is reduced to half in as little as an hour of cooling post irradiation, and consistent with the LOCA approach described in the SAR.

[....]

Figure 22-8: Maximum fuel temperature versus time for air cooled event scenarios