TEXAS ENGINEERING EXPERIMENT STATION
TEXAS A&M UNIVERSITY SYSTEM
RESEARCH REACTOR
LICENSE NO. R-83
DOCKET NO. 50-128

TECHNICAL RAI RESPONSES (DATED 11/21/2011)

REDACTED VERSION*

SECURITY-RELATED INFORMATION REMOVED

*REDACTED TEXT AND FIGURES BLACKED OUT OR DENOTED BY BRACKETS

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November 21, 2011

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

2011-0051

Subject: Response to NRC Requests for Additional Information Questions 1 through 4 and Updated Technical Specifications for the Nuclear Science Center Reactor (NSCR, License No. R-83, Docket 50-128)

To Whom It May Concern:

The Texas A&M University System, Texas Engineering Experiment Station (TEES), Nuclear Science Center (NSC, License No. R-83) operates a LEU, 1MW, TRIGA reactor under timely renewal. In December, 2003 the NSC submitted a Safety Analysis Report (SAR) as part of the license renewal process. In December, 2005 a conversion SAR (Chapter 18) was submitted resulting in an order to convert from the NRC. In July 2009, the NSC submitted an updated SAR, dated June 2009, to the Nuclear Regulatory Commission (NRC). This updated 2009 version of our SAR incorporated the information from the conversion SAR and the startup of the new LEU reactor core. On September 29, 2011 the NRC submitted a Request for Additional Information as a part of the review process. This request included 4 questions about the technical aspects of the NSC's SAR submittal. Attached to this letter are the NSC's response to Questions 1-4 of the NRC's RAIs and an updated version of the NSC's Technical Specifications.

If you have any questions, please contact Jim Remlinger, Jerry Newhouse, or W. Dan Reece at 979-845-7551.

I declare under penalty of perjury that the foregoing is true and correct. Executed on November 21, 2011.

W. D. Reece

W. D. Reece
Director, Nuclear Science Center

Xc: 2.11/Central File
Duane Hardesty, NRC Project Manager

A020
NRR

[redacted]

RAI 1

NUREG 1537, Part 1, Section 4.3, Reactor Tank and Pool, states that the applicant should present all information about the pool necessary to ensure its integrity and should assess the possibility of uncontrolled leakage of contaminated primary coolant and should discuss preventive and protective features. Chapter 4 of your safety analysis report (SAR) does not provide this information. The following information is needed to complete our review:

a. Please provide a discussion of the reactor pool water level monitoring system, alarm levels and required responses from the reactor operator and/or university personnel for remote alarm signal. Please provide the minimum detectable leakage as well as an estimate of the amount of time necessary to detect the leakage.

b. Please provide a discussion of the potential drainage pathways of reactor pool water leakage, operator response, and radioactivity monitoring. If water enters the uncontrolled environment, please discuss the radiological impact.

Response A

The reactor pool water level is monitored in two different ways. Procedurally, during each day's operation the level is read and recorded. In our updated TS we propose to add a surveillance requirement that this be done at least weekly. However, we have every intention of continuing the daily record as we have done for years. The minimum change in pool level we can observe is about 500 gallons, which corresponds to about 0.15 inches. There is also a float switch currently set at 3 feet below the full pool level, but when the new TS go into effect it will be set at 6 feet. This switch initiates a local and remote alarm signal. The reactor operators' required response can be found in the emergency plan, but to summarize they shut down the reactor, turn off all pumps, install a cover over the primary cooling intake, calculate the rate to leakage to determine whether it exceeds makeup capacity, begin water addition, and investigate the source of the leakage. During after-hours, the remote monitor will notify the first operator on the call list who will respond and complete the above steps.

Response B

Any water leaked from our pool will collect in our liquid waste sump. This sump pumps to our controlled liquid waste tanks. These tanks are sampled prior to being released for both radiological and chemical content and the release must be approved by the RSO. Even if this system were not in place, in our new TS there will be an LCO requiring our pool water to be releasable under Table 2 in Appendix B of 10 CFR 20.

[redacted]

RAI 2a

The proposed TS 3.6.2.1.d states that:

Cumulative exposures for explosive materials in quantities greater than 25 milligrams (TNT-equivalent) shall not exceed 10^{12} n/cm^2 for neutron or 25 Roentgen for gamma exposures.

Please provide a basis/justification for this limitation.

Response

It has been shown that there is little effect on explosive stability below doses of 10^6R. (Kaufman J.V.R. (Jul. 29, 1958). The Effect of Nuclear Radiation on Explosives. *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Science, Vol. 246*(No. 1245, A Discussion on the Initiation and Growth of Explosion in Solids).

Urizar M.J., Loughran E.D., Smith L.C. (Jan. 01, 1960). A Study of the Effects of Nuclear Radiation on Organic Explosives.

Our justification for the allowable doses here is that they are very much less than 10^6R.

RAI 2b

In addition, the proposed TS 3.6.2.2 states that:

Each fueled experiment shall be controlled such that the total inventory of iodine isotopes 131 through 135 in the experiment is no greater than 10 Ci.

Please provide an analysis to demonstrate that a failure in a fueled experiment will not lead to consequences beyond those of the maximum hypothetical accident (MHA).

Response

We will reduce the total inventory of iodine isotopes 131 through 135 for each experiment from 10 Ci to 1 Ci. It is assumed that the fuel experiment failure would occur in the pool. The release fraction of 10^-3 is very conservative for an underwater release and in comparison to the MHA.

Fueled Experiment Failure

Iodine release

10^-3 release fraction

(1 Ci)*(10^-3) = 0.0001 Ci = **1 mCi**

[redacted]

MHA

Iodine release

[redacted]

Exposure Criteria	Whole Body Dose (mR)	Thyroid Dose (mR)
Maximum exposure to operating personnel at 5 minutes after release	6.2	2810
Maximum exposure to personnel in unrestricted area	0.4	14
Exposure to personnel in nearest permanently occupied area (nearest resident)	0.1	4

Comparison

[redacted]

Exposure Table for Fueled Experiment Failure

Exposure Criteria	Whole Body Dose (mR)	Thyroid Dose (mR)
Maximum exposure to operating personnel at 5 minutes after release	(6.2)*(0.0052) = **0.032**	(2810)*(0.0052) =**14.6**
Maximum exposure to personnel in unrestricted area	(0.4)*(0.0052) = **0.002**	(14)*(0.0052) = **0.073**
Exposure to personnel in nearest permanently occupied area (nearest resident)	(0.1)*(0.0052) =**0.0005**	(4)*(0.0052) = **0.02**

Conclusion

The maximum fueled experiment failure would result in a release comparable to about 0.5% of the MHA. Therefore, it does not constitute a danger greater than that analyzed in the MHA.

Nearest Resident Exposure Thyroid									
Nuclide	**Inventory (Ci)**	**Release (Ci)**	**Concentration (μCi/cc)**	**Activity Uptake (μCi)**	**Activity Uptake (Bq)**	**Dose Conversion Factor (Sv/Bq)**	**Dose (SV)**	**Dose (Rem)**	**Dose (mRem)**
I-131	[redacted]	[redacted]	[redacted]	5.09E-04	18.82771429	2.92E-07	5.50E-06	5.50E-04	5.50E-01
I-132	[redacted]	[redacted]	[redacted]	7.64E-04	28.2828	1.74E-09	4.92E-08	4.92E-06	4.92E-03
I-133	[redacted]	[redacted]	[redacted]	1.18E-03	43.70228571	4.86E-08	2.12E-06	2.12E-04	2.12E-01
I-134	[redacted]	[redacted]	[redacted]	1.36E-03	50.27137143	2.88E-10	1.45E-08	1.45E-06	1.45E-03
I-135	[redacted]	[redacted]	[redacted]	1.11E-03	40.89874286	8.46E-09	3.46E-07	3.46E-05	3.46E-02

Sum:	**8.03E-04**	**0.80**
5 min Sum:	4.02E-03	4.02

Maximum Exposed Member of the Public Thyroid									
Nuclide	Inventory (Ci)	Release (Ci)	Concentration (μCi/cc)	Activity Uptake (μCi)	Activity Uptake (Bq)	Dose Conversion Factor (Sv/Bq)	Dose (SV)	Dose (Rem)	Dose (mRem)
I-131	[redacted]	[redacted]	[redacted]	1.78E-03	65.897	2.92E-07	1.92E-05	1.92E-03	1.92E+00
I-132	[redacted]	[redacted]	[redacted]	2.68E-03	98.9898	1.74E-09	1.72E-07	1.72E-05	1.72E-02
I-133	[redacted]	[redacted]	[redacted]	4.13E-03	152.958	4.86E-08	7.43E-06	7.43E-04	7.43E-01
I-134	[redacted]	[redacted]	[redacted]	4.76E-03	175.9498	2.88E-10	5.07E-08	5.07E-06	5.07E-03
I-135	[redacted]	[redacted]	[redacted]	3.87E-03	143.1456	8.46E-09	1.21E-06	1.21E-04	1.21E-01

Sum:	**2.81E-03**	**2.81**
5 min sum:	1.41E-02	14.05

Maxiumum Exposed Person Thyroid								
Nuclide	**Inventory (Ci)**	**Release (Ci)**	**Concentration (µCi/cc)**	**Activity Uptake (µCi)**	**Activity Uptake (Bq)**	**Dose Conversion Factor (Sv/Bq)**	**Dose (SV)**	**Dose (Rem)**
I-131	[redacted]	[redacted]	[redacted]	3.56E-01	1.32E+04	2.92E-07	3.85E-03	3.85E-01
I-132	[redacted]	[redacted]	[redacted]	5.35E-01	19797.96	1.74E-09	3.44E-05	3.44E-03
I-133	[redacted]	[redacted]	[redacted]	8.27E-01	30591.6	4.86E-08	1.49E-03	1.49E-01
I-134	[redacted]	[redacted]	[redacted]	9.51E-01	35189.96	2.88E-10	1.01E-05	1.01E-03
I-135	[redacted]	[redacted]	[redacted]	7.74E-01	28629.12	8.46E-09	2.42E-04	2.42E-02

Sum:	**0.56**

5 min Sum: 2.81096104

Nearest Resident Exposure Whole Body							
Nuclide	Inventory (Ci)	Release (Ci)	Concentration (µCi/cc)	Concentration (Bq/m^3)	DCF (Sv/s per Bq/m^3)	External Dose (Sv/s)	External Dose (mR/hr)
Br-83	[redacted]	[redacted]	[redacted]	[redacted]	3.82E-16	1.34E-14	4.81E-06
Br-84	[redacted]	[redacted]	[redacted]	[redacted]	9.41E-14	6.40E-12	2.30E-03
Br-85	[redacted]	[redacted]	[redacted]	[redacted]	3.56E-15	2.85E-13	1.02E-04
I-131	[redacted]	[redacted]	[redacted]	[redacted]	1.82E-14	3.46E-12	1.25E-03
I-132	[redacted]	[redacted]	[redacted]	[redacted]	1.12E-13	3.20E-11	1.15E-02
I-133	[redacted]	[redacted]	[redacted]	[redacted]	2.94E-14	1.30E-11	4.67E-03
I-134	[redacted]	[redacted]	[redacted]	[redacted]	1.30E-13	6.60E-11	2.38E-02
I-135	[redacted]	[redacted]	[redacted]	[redacted]	7.98E-14	3.30E-11	1.19E-02
I-136	[redacted]	[redacted]	[redacted]	[redacted]	1.35E-13	2.86E-11	1.03E-02
Kr-83m	[redacted]	[redacted]	[redacted]	[redacted]	1.50E-18	5.25E-17	1.89E-08
Kr-85m	[redacted]	[redacted]	[redacted]	[redacted]	7.48E-15	5.98E-13	2.15E-04
Kr-85	[redacted]	[redacted]	[redacted]	[redacted]	1.19E-16	5.94E-16	2.14E-07
Kr-87	[redacted]	[redacted]	[redacted]	[redacted]	4.12E-14	6.73E-12	2.42E-03
Kr-88	[redacted]	[redacted]	[redacted]	[redacted]	1.02E-13	2.36E-11	8.50E-03
Kr-89	[redacted]	[redacted]	[redacted]	[redacted]	9.21E-14	2.77E-11	9.97E-03
Kr-90	[redacted]	[redacted]	[redacted]	[redacted]	6.07E-14	1.98E-11	7.14E-03
Kr-91	[redacted]	[redacted]	[redacted]	[redacted]			
Xe-131m	[redacted]	[redacted]	[redacted]	[redacted]	3.89E-16	8.10E-16	2.91E-07
Xe-133m	[redacted]	[redacted]	[redacted]	[redacted]	1.37E-15	1.75E-14	6.30E-06
Xe-133	[redacted]	[redacted]	[redacted]	[redacted]	1.56E-15	6.71E-13	2.42E-04
Xe-135m	[redacted]	[redacted]	[redacted]	[redacted]	2.04E-14	1.56E-12	5.63E-04
Xe-135	[redacted]	[redacted]	[redacted]	[redacted]	1.19E-14	3.49E-12	1.26E-03
Xe-137	[redacted]	[redacted]	[redacted]	[redacted]	9.06E-15	3.64E-12	1.31E-03
Xe-138	[redacted]	[redacted]	[redacted]	[redacted]	5.77E-14	2.41E-11	8.67E-03
Xe-139	[redacted]	[redacted]	[redacted]	[redacted]			
Xe-140	[redacted]	[redacted]	[redacted]	[redacted]			

Sum:	[redacted]	[redacted]	[redacted]				**0.11**

Maximum Exposed Member of the Public Whole Body							
Nuclide	Inventory (Ci)	Release (Ci)	Concentration (μCi/cc)	Concentration (Bq/m³)	DCF (Sv/s per Bq/m³)	External Dose (Sv/s)	External Dose (mR/hr)
Br-83	[redacted]	[redacted]	[redacted]	[redacted]	3.82E-16	4.68E-14	1.68E-05
Br-84	[redacted]	[redacted]	[redacted]	[redacted]	9.41E-14	2.24E-11	8.06E-03
Br-85	[redacted]	[redacted]	[redacted]	[redacted]	3.56E-15	9.96E-13	3.59E-04
I-131	[redacted]	[redacted]	[redacted]	[redacted]	1.82E-14	1.21E-11	4.36E-03
I-132	[redacted]	[redacted]	[redacted]	[redacted]	1.12E-13	1.12E-10	4.03E-02
I-133	[redacted]	[redacted]	[redacted]	[redacted]	2.94E-14	4.54E-11	1.63E-02
I-134	[redacted]	[redacted]	[redacted]	[redacted]	1.30E-13	2.31E-10	8.31E-02
I-135	[redacted]	[redacted]	[redacted]	[redacted]	7.98E-14	1.15E-10	4.15E-02
I-136	[redacted]	[redacted]	[redacted]	[redacted]	1.35E-13	1.00E-10	3.60E-02
Kr-83m	[redacted]	[redacted]	[redacted]	[redacted]	1.50E-18	1.84E-16	6.61E-08
Kr-85m	[redacted]	[redacted]	[redacted]	[redacted]	7.48E-15	2.09E-12	7.53E-04
Kr-85	[redacted]	[redacted]	[redacted]	[redacted]	1.19E-16	2.08E-15	7.49E-07
Kr-87	[redacted]	[redacted]	[redacted]	[redacted]	4.12E-14	2.36E-11	8.49E-03
Kr-88	[redacted]	[redacted]	[redacted]	[redacted]	1.02E-13	8.26E-11	2.97E-02
Kr-89	[redacted]	[redacted]	[redacted]	[redacted]	9.21E-14	9.70E-11	3.49E-02
Kr-90	[redacted]	[redacted]	[redacted]	[redacted]	6.07E-14	6.94E-11	2.50E-02
Kr-91	[redacted]	[redacted]	[redacted]	[redacted]			
Xe-131m	[redacted]	[redacted]	[redacted]	[redacted]	3.89E-16	2.83E-15	1.02E-06
Xe-133m	[redacted]	[redacted]	[redacted]	[redacted]	1.37E-15	6.12E-14	2.20E-05
Xe-133	[redacted]	[redacted]	[redacted]	[redacted]	1.56E-15	2.35E-12	8.46E-04
Xe-135m	[redacted]	[redacted]	[redacted]	[redacted]	2.04E-14	5.47E-12	1.97E-03
Xe-135	[redacted]	[redacted]	[redacted]	[redacted]	1.19E-14	1.22E-11	4.40E-03
Xe-137	[redacted]	[redacted]	[redacted]	[redacted]	9.06E-15	1.28E-11	4.59E-03
Xe-138	[redacted]	[redacted]	[redacted]	[redacted]	5.77E-14	8.43E-11	3.03E-02
Xe-139	[redacted]	[redacted]	[redacted]	[redacted]			
Xe-140	[redacted]	[redacted]	[redacted]	[redacted]			
Sum:	[redacted]	[redacted]	[redacted]				**0.37**

Maxium Exposed Person Whole Body							
Nuclide	Inventory (Ci)	Release (Ci)	Concentration (µCi/cc)	Concentration (Bq/m^3)	DCF (Sv/s per Bq/m^3)	External Dose (Sv/s)	External Dose (mR/hr)
Br-83	[redacted]	[redacted]	[redacted]	[redacted]	3.82E-16	9.35E-12	3.37E-03
Br-84	[redacted]	[redacted]	[redacted]	[redacted]	9.41E-14	4.48E-09	1.61E+00
Br-85	[redacted]	[redacted]	[redacted]	[redacted]	3.56E-15	1.99E-10	7.17E-02
I-131	[redacted]	[redacted]	[redacted]	[redacted]	1.82E-14	2.42E-09	8.72E-01
I-132	[redacted]	[redacted]	[redacted]	[redacted]	1.12E-13	2.24E-08	8.06E+00
I-133	[redacted]	[redacted]	[redacted]	[redacted]	2.94E-14	9.08E-09	3.27E+00
I-134	[redacted]	[redacted]	[redacted]	[redacted]	1.30E-13	4.62E-08	1.66E+01
I-135	[redacted]	[redacted]	[redacted]	[redacted]	7.98E-14	2.31E-08	8.30E+00
I-136	[redacted]	[redacted]	[redacted]	[redacted]	1.35E-13	2.00E-08	7.20E+00
Kr-83m	[redacted]	[redacted]	[redacted]	[redacted]	1.50E-18	3.67E-14	1.32E-05
Kr-85m	[redacted]	[redacted]	[redacted]	[redacted]	7.48E-15	4.18E-10	1.51E-01
Kr-85	[redacted]	[redacted]	[redacted]	[redacted]	1.19E-16	4.16E-13	1.50E-04
Kr-87	[redacted]	[redacted]	[redacted]	[redacted]	4.12E-14	4.71E-09	1.70E+00
Kr-88	[redacted]	[redacted]	[redacted]	[redacted]	1.02E-13	1.65E-08	5.95E+00
Kr-89	[redacted]	[redacted]	[redacted]	[redacted]	9.21E-14	1.94E-08	6.98E+00
Kr-90	[redacted]	[redacted]	[redacted]	[redacted]	6.07E-14	1.39E-08	5.00E+00
Kr-91	[redacted]	[redacted]	[redacted]	[redacted]			
Xe-131m	[redacted]	[redacted]	[redacted]	[redacted]	3.89E-16	5.67E-13	2.04E-04
Xe-133m	[redacted]	[redacted]	[redacted]	[redacted]	1.37E-15	1.22E-11	4.41E-03
Xe-133	[redacted]	[redacted]	[redacted]	[redacted]	1.56E-15	4.70E-10	1.69E-01
Xe-135m	[redacted]	[redacted]	[redacted]	[redacted]	2.04E-14	1.09E-09	3.94E-01
Xe-135	[redacted]	[redacted]	[redacted]	[redacted]	1.19E-14	2.44E-09	8.80E-01
Xe-137	[redacted]	[redacted]	[redacted]	[redacted]	9.06E-15	2.55E-09	9.18E-01
Xe-138	[redacted]	[redacted]	[redacted]	[redacted]	5.77E-14	1.69E-08	6.07E+00
Xe-139	[redacted]	[redacted]	[redacted]	[redacted]			
Xe-140	[redacted]	[redacted]	[redacted]	[redacted]			
Sum:	[redacted]	[redacted]	[redacted]				**74.24**

Dose in 5 minutes: 6.19

[redacted]

RAI 3

NUREG-1537 Chapter 13, Accident Analysis, recommends MHA doses analysis to the public. The MHA analysis presented in the TAMU TRIGA SAR, as supplemented, is incomplete in that; (1) while providing considerable information, it does not provide a clear presentation of the analyzed scenario, and (2) it does not discuss the dose to on site, non-occupational individuals in the Laboratory Building such as students, faculty, visitors, etc.

a. Please provide a dose assessment for the maximum exposed individual member of the public in the Laboratory Building. Please describe the assumptions used and any systems, plans, procedures, or stay times for which credit is taken in the analysis.

b. If evacuation of these areas is necessary following an MHA, please show that this contingency is discussed in the emergency plan.

c. Please discuss the assumptions used in the dose assessment for the members of the public such as ground release rate, exposure pathways (inhalation, immersion), exposure time for members of public, and dose conversion factors.

Response A and C

Note: In addition to the below please see the attached Excel workbook which accounts for dose contribution on a nuclide basis.

Using the data in Table 13-1, the saturated activities of the significant fission products for a single LEU 30/20 fuel element at 1.0 MW are:

1. Total iodine fission products – [redacted]
2. Total halogen (Br and I) fission products – [redacted]
3. Total gaseous (Kr and Xe) fission product – [redacted]

Applying the release fraction of 2.6×10^{-5} to the total inventory in a single element operating at 1.0 MW yields the following activities that would be released in a cladding failure:

1. Total iodine activity [redacted]
2. Total halogen activity - [redacted]
3. Total gaseous activity - [redacted]

If the release accident occurred with water in the pool, the halogens will remain in the water. The resulting concentration would be [redacted] Within 24 hours, this value would decay to [redacted] The demineralizer system (Section 5.4.1) would remove these soluble fission products and they would eventually be transferred to the liquid waste system.

NSC calculated the results of the release of fission products from a single fuel element without water in the reactor pool, and with the ventilation system shut down[i]. The only case where

[redacted]

significant exposure occurs requires the simultaneous failure of the fuel element clad, catastrophic failure of the pool and liner, and a failure of the ventilation system with personnel remaining within the reactor facility for a period of five minutes after release.

Calculations were performed to determine the whole body dose and thyroid dose to an individual due to gamma emitters uniformly dispersed throughout the volume of the reactor building. The maximum stay time in the reactor building is assumed to be 5 minutes following the release. We assumed that 100 % of volatiles escape into the reactor building volume when the pool water is lost. If the volatiles were dispersed uniformly in the reactor building, the resulting concentration is calculated to be [redacted]. The maximum external dose from submersion in these photon emitters was calculated to be 6.2 mR.

The thyroid dose to an individual in the reactor building is calculated from the concentrations of various iodine isotopes released from the initial inventory and dispersed throughout the volume of the reactor building. Assuming standard man breathing rate the resulting dose is calculated from using the flux to dose conversion factor from Federal Guidance Report 11 for each iodine isotope. For an individual remaining in the reactor building for 5 minutes following release, the thyroid dose is calculated to be 2810 mrem.

The dose assessment for the members of the public outside the fence line was calculated assuming that all the fission products are released to the atmosphere outside the reactor building. Worst case conditions were assumed: a wind speed of 2 m/s and stability class F and with ventilation system shutdown, all releases at ground level, leaking from the reactor building, and the unrestricted area was occupied during the entire release. No credit was given for iodine plate out or decay of isotopes during hold up. Using these assumptions, the dose rate to an individual just outside the site boundary at 100 m from the reactor building was calculated to be 0.4 mrem/hr and the thyroid dose calculated to be 14 mrem. Conservative calculations were also performed to determine the whole body dose and the thyroid dose to personnel in the permanently occupied area about 800 m away from the building. The whole body dose rate was calculated to be 0.1 mR/hr and thyroid dose was calculated to be 4 mrem.

Members of the general public can also be present in the laboratory building adjacent to the reactor building. After evacuation of the confinement building, our Emergency Plan calls for evacuation of the laboratory building if the dose rate in the laboratory building exceeds 5 mrem. We assume under these conditions that evacuation would take at most 20 minutes. Because of the shelter provided by the building, the dose rates inside the building are assumed to be no worse than dose rates at the fenceline directly under the plume where we assumed occupation during the entire event. We are taking these unrestricted access doses as an upper bound on personnel in the laboratory building.

Table 13-2 shows the calculated exposure to population outside the building and exposure to operating personnel inside the facility. The exposure to personnel in unrestricted areas during the accident is calculated to be minimal. Thus, no realistic hazard of consequence will result from the DBA.

[redacted]

Table 13-2: Summary of Radiation Exposures Following the Release of Fission Products from a Single Fuel Element

Exposure Criteria	Whole Body Dose	Thyroid Dose
	mrem	mrem
Maximum exposure to operating personnel at 5 minutes after release	6.2	2810
Maximum exposure to personnel in unrestricted area at 1 hour after release	0.4	14
Exposure to personnel in nearest permanently occupied area (nearest resident) at 1 hour after release	0.1	4
Exposure to personnel inside the Laboratory Building	0.4	14

[i] Vasudevan, L., "Radiation Exposure Following the release of Fission Products During a Design Basis Accident Condition," Nuclear Science Center Internal Report, August 2006.

Response B

Site evacuation is discussed in Emergency Plan 7.7.3 Corrective Actions for an Alert which informs SOP IX-B-2 Site Evacuation and Area Control.

[redacted]

RAI 4

NUREG 1537, Chapter 11, Radiation Protection Program and Waste Management, states that the applicant should describe airborne radioactive sources. The description should show that the facility design ensures that doses to the staff and the public will not exceed 10 CFR Part 20 limits and that its ALARA [As Low As Reasonably Achievable] requirements for effluents are satisfied. Chapter 11 of your SAR, as supplemented, while providing considerable information, is incomplete in that it does not provide a bounding calculation for Argon-41 doses to the staff and to members of the public.

The following information is needed to complete the review:

a. Please provide a bounding calculation of Argon-41 doses to staff members (occupational dose) and members of the public (Laboratory Building, fence, nearest residence). Please discuss the assumptions used in the dose models such as, wind directions, air stability model, exposure pathways (inhalation, immersion, or sky shine), and the use of appropriate dose conversion factors.

b. In the bounding calculation above, please consider all modes of operation (e.g., against and away from thermal column).

Response 4 A and B

The exhaust rate from the stack is 8000 ft^3/minute or 1.19E14 cc/year. If 30 Ci of Ar-41 were released uniformly over the whole year (TS 3.7), the concentration would be 2.5E-7 uCi/cc in the stack. The dilution factor for the distance to the fence line is 200. The effluent concentration for Ar-41 is 1E-8 uCi/cc, so the dose to the public for continuous exposure over the entire year is 6.3 mrem. If the building concentration is taken as the same as the stack concentration, then using the DAC value of 3E-6 we would calculate a dose of 416 mrem to an NSC worker if in confinement for 2000 hrs/year.

The reactor building has a volume of 180,000 ft^3 or 5.1E9 cc. If 30 Ci were somehow released into the building all at once, the average concentration would be 5.9E-3 uCi/cc. The dose rate would be 5 rem/hour. Evacuation takes less than 5 minutes so dose to individual workers would be less than 416 mrem. If we assume that it takes 30 seconds to shutdown the ventilation system and isolate the building, then 4000 ft^3 (1.1E8 cc) of Ar-41 at 5.9E-3 uCi/cc leaves the stack, or 649 mCi of Ar-41. The dose to the general public calculated by the EPA COMPLY code from 30 Ci of Ar-41 released through the stack is 1.1 mrem, so the dose from 649 mCi would be 0.02 mrem.

We again assume that members of the general public in the laboratory building are exposed less than worst case fence line exposures.

[redacted]

All modes of operation at the NSC including thermal column operations produce air concentrations of less than 2E-5 uCi/cc (our alarm point) and typically an order of magnitude less.