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January 27, 2012

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

Reference: U.S. Geological Survey TRIGA Reactor (GSTR), Docket 50-274, License R-113
Request for Additional Information (RAI) dated September 29, 2010

Subject:Response to Question 18 of the Referenced RAI

Mr. Wertz:

Question 18: GSTR SAR Subsection 13.2.5.2 uses a gap release fraction of $1.22x10^{-4}$ which is higher than the gap release fraction used in GSTR SAR Subsection 13.2.1.2 for the MHA ($1.66x10^{-5}$). Please provide an analysis using a consistent gap release fraction.

Response: The Geological Survey TRIGA Reactor (GSTR) Safety Analysis Report (SAR) section 13.2.5.2 calculates the dose to members of the public and GSTR staff in the reactor bay during an accident scenario where the fuel cladding fails in the water. The analysis included work shown in section 13.2.1.1, which was updated in response to RAI question 15.3. Section 13.2.5.2 over-conservatively assumed a fuel temperature of 500°C to calculate the gap release fraction, which is unrealistically too high and should actually be the same temperature that was used in section 13.2.1.1 of 350°C. The corresponding calculations and explanations are given below in the newly revised section 13.2.5.2, using a consistent gap release fraction of $1.66x10^{-5}$.

13.2.5.2 Accident Analysis and Determination of Consequences

All three scenarios mentioned in the previous paragraph result in a single fuel element failure in water. In the unlikely event that this failure occurred in air, it would be the MHA analyzed in Section 13.2.1.2.

At various points in the lifetime of the GSTR, fuel elements are moved to new positions or removed from the core. Fuel elements are moved only during periods when the reactor is shutdown.

Assumptions for this accident are almost exactly the same as those used for the MHA, except for one thing: the pool water will retain most of the halogens, resulting in a significant reduction in the halogen dose contribution.

The assumptions for this accident and the method of analysis of this accident were described in Section 13.2.1.2.

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The results for this accident (with water in tank) are given in Tables 13.13 to 13.14.

The results of this accident show that under all possibilities the radiation doses to the general public are well below the annual limits in 10 CFR 20, with the maximum dose being 0.015 mrem TEDE at 250 meters from the exhaust stack, for the worst case scenario. The occupational radiation doses to workers in the reactor room are also well below the occupational annual limits in 10 CFR 20, with the maximum dose being 260 mrem TEDE for a 5-minute exposure. Five minutes is more than enough time for workers to move the 30 feet or less to evacuate the room if such an accident were to occur.

Table 13.13: Occupational $CDE_{Thyroid}$ and TEDE in the Reactor Room Following a Single Element Failure in Air and Water

Reactor Room Occupancy (minutes)	CDEThyroid (no water) (mrem)	TEDE (no water) (mrem)	CDEThyroid (water) (mrem)	TEDE (water) (mrem)
2	1534	263	77	104
5	3835	657	192	260

Table 13.14: Radiation Doses to Members of the General Public Following a Single Element Failure in Water

Distance (m)	CDEThyroid (mrem)	TEDE (mrem)
10	0.0	0.0
50	1.6e-8	2.9e-9
100	7.0e-3	1.2e-3
150	0.048	8.3e-3
200	0.078	0.013
250	0.088	0.015
300	0.087	0.014
350 (fence)	0.080	0.013
640 (residence)	0.041	6.4e-3
720 (school)	0.035	5.3e-3

Since most of the halogens released from the fuel element will be retained in the primary water, the majority of this activity will end up in the demineralizer tank. The exposure rate from the demineralizer tank can be estimated by

$$DR = 6CEN \text{ (R/h at 1 foot)}, \tag{13.19}$$

where:

C = number of halogen curies retained in the demineralizer tank (Ci);
E = energy of gamma rays (MeV) = 1; and
N = number of gamma rays per disintegration = 1.

From Table 13.1, the total saturated activity of the halogens is 5,805 curies. Of this, 1.66×10^{-5} is released to the gap (from equation 13.1 using a fuel temperature of 350°C), 0.5 of the gap activity is released to the water, and 0.95 of this remains in the water. Thus, the number of curies retained in the demineralizer tank is 0.046 Ci. The assumption that the average energy of the gamma rays from the halogens is 1 MeV is conservative. Thus, the dose rate equals 0.27 R/hr at one foot.

Surrounding the sides of the GSTR demineralizer tank is 0.5 inch of lead (no shielding on top). The mass attenuation factor for lead is 0.0708 cm^2/g, and the density of lead is 11.34 g/cm^3 [1]. The overall attenuation factor for the lead shield is about 0.361. This reduces the exposure rate to about 97.4 mR/hr at one foot.

A fuel loading error is another potential way that a fuel element might overheat and result in a cladding failure. The GSTR Technical Specifications require that if a core containing aluminum-clad fuel is used, the aluminum-clad fuel must be in the outer two rings of the core grid. Loading aluminum-clad fuel in the inner rings of the core could potentially result in cladding failure due to dimensional changes of the element during accident conditions.

[1] Radiological Health Handbook, Revised Edition, U.S. Department of Health, Education, and Welfare, U.S. Government Printing Office, 1970, pp.137-140.

Sincerely,

Tim DeBey

Tim DeBey

USGS Reactor Supervisor

I declare under penalty of perjury that the foregoing is true and correct.
Executed on 1/27/12

Copy to:

Betty Adrian, Reactor Administrator, MS 975
USGS Reactor Operations Committee