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May 18, 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 March 21, 2012

Subject: Responses to Questions 26 and 27 of the Referenced RAI

Mr. Wertz:

Here are the responses to Question 26, parts a through e:

a. USGS SAR, Section 11.1.1.1.1 states that the whole body dose from Ar-41 is a factor of 48.7 times less than the Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20, Appendix B, values. Please provide the assumptions, calculations, and justification for the derivation of this factor.

The 10CFR 20, Appendix B values are based on the assumption that a person is submersed in a semi-infinite hemisphere of Ar-41 at the concentration shown. Because of the small physical size of the GSTR reactor bay, and the fact that Ar-41 provides a submersion dose, this assumption is a significant overestimate of the actual whole body dose received by a person in the reactor room. We can simulate our reactor bay by a finite hemisphere with a volume equivalent to the actual reactor bay. The calculations used to determine the magnitude of this overestimate are:

$$\frac{\Phi_{inf}}{\Phi_r} = \frac{1}{1-e^{-\mu r}}, \quad \text{where}$$

A020
NRR

Φ_{inf} = the semi-infinite hemisphere gamma flux,
Φ_r = the gamma flux at radius (r)
μ = the attenuation coefficient of air (5.6 e-5 cm^{-1}), and
r = the finite reactor bay hemisphere radius (550 cm).

The resultant gamma flux overestimate ratio is 33, thus the whole body dose from 1 DAC of Ar-41 in the GSTR reactor bay is 33 times less than that estimated in 10CFR 20. This factor of 33 is a correction from the factor of 48.7 given in the original SAR submission.

b. USGS SAR, Section 11.1.1.1.1 states that an individual spending 8 hours per week with an Ar-41 air concentration of 4.35 x 10^{-6} micro-Curies per milliliter (μCi/mL) would receive a radiation dose of about 66 milli-Roentgen Equivalent Man (mrem) per year. Please provide the assumptions, calculations, and justification for this dose estimate.

From the answer to part a (above), the Ar-41 dose rate in the GSTR reactor bay per DAC-hr is a factor of 33 less than the assumed conditions in 10CFR 20. In addition, one DAC-hr (at an Ar-41 level of 3e-6 μCi/ml) has an assumed dose rate per 10CFR 20 of 5000 mRem/2000 DAC-hrs, or 2.5 mRem per DAC-hr. The typical GSTR reactor bay Ar-41 concentration at full power operation is

$$4.35\times10^{-6}\ \mu Ci/ml \div 3\times10^{-6}\ \mu Ci/ml, \text{ or } 1.45 \text{ DAC.}$$

As result, a person standing in the middle of the GSTR reactor bay for 8 hours per week at 1.45 DAC would receive an annual dose equal to:

(2.5 mRem/DAC-hr) (1/33 factor)(1.45 DAC)(8 hrs/week)(52 weeks) = 45.7 mRem

This annual dose of 45.7 mRem is a correction to the 66 mRem given in our submitted SAR.

c. USGS SAR, Section 11.1.1.1.1 describes an accident involving flooding of the rotary specimen rack releasing Ar-41 into the reactor bay, with an estimated radiation dose of 17.9 mrem to an individual in the center of the reactor bay, and an estimated radiation dose of 208 mrem if the release involved 10 Ci of Ar-41. Please provide the assumptions, calculations, and justification supporting these estimated radiation doses.

Accidental flooding of an air-filled experimental cavity could release larger than normal quantities of Ar-41 into the reactor bay. Flooding of the rotary specimen rack could result in the acute release of up to 860 mCi into the reactor bay. If the bay ventilation system is operating normally, this activity will remain in the room for about 12 minutes. The maximum Ar-41 concentration in the room would be 2.46×10^{-3} μCi/ml (820 DAC), assuming uniform mixing. Using the finite hemisphere cloud approximation (see answer to part a, above), and conservatively assuming that the Ar-41 concentration stays at the maximum level for 12 minutes, the discharge of 860 mCi into the reactor bay would give a whole body dose of about 12.4 mrem to a person positioned in the center of the room.

(2.5 mRem/DAC-hr) (1/33 factor)(820 DAC)(0.2 hr) = 12.4 mRem

The same accident, releasing 10 Ci of Ar-41 would give a whole body dose of about 144 mrem. This dose is well below the occupational limits of 10CFR 20.

(12.4 mRem * 10 Ci/0.86 Ci = 144 mRem)

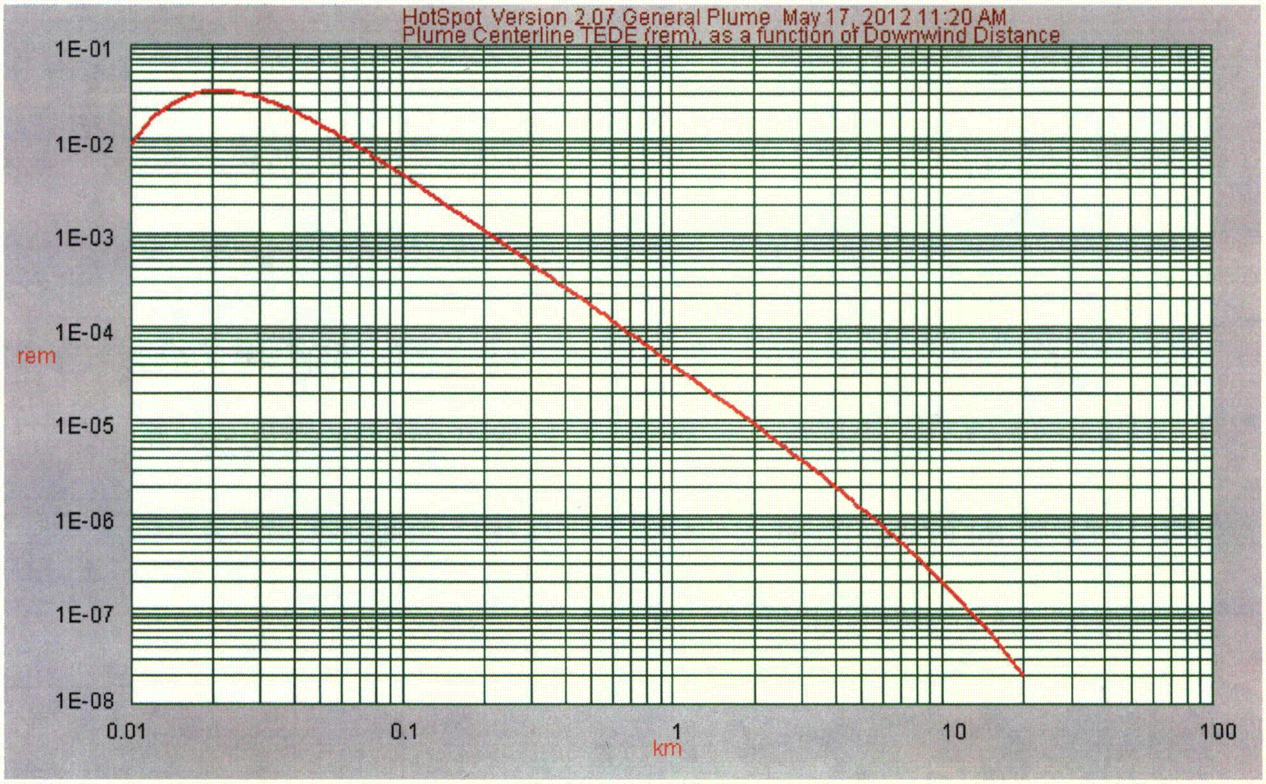
d. **USGS SAR, Section 11.1.1.1.1 describes the routine exposure of personnel in unrestricted areas from Ar-41 releases assuming the person is standing next to the reactor building, at a distance of 8 meters from the release point. An annual release of 25 Ci of Ar-41 results in an whole body dose of less than 17 mrem per year a person near the building wall. Please provide the assumptions, calculations, and justification supporting the estimation of doses in the unrestricted area from annual operational releases of AR-41 to the atmosphere.**

The scenario of an annual 25 Ci release of Ar-41 was reanalyzed using the DOE HOTSPOT computer code (version 2.07), general plume model. This analysis made conservative assumptions about meteorological conditions, release amount, and the location of the receptor at the maximum dose point. The results are given below, showing input parameters and a graph of the dose versus downwind location. It is conservatively assumed that the receptor is always downwind of the release point and at the center of the plume, for the entire year. The downwind distance for the maximum dose is 34 meters and the maximum dose is 7.4 mRem.

HotSpot Version 2.07 General Plume

May 17, 2012 11:39 AM
Source Material : Ar-41 1.827h
Material at Risk : 2.5000E+01 Ci
Damage Ratio : 1.000
Leakpath Factor : 1.000
Airborne Fraction : 1.000
Respirable Fraction : 1.000
Respirable Release Fraction: 1.000
Physical Stack Height : 6.4 m
Stack Exit Velocity : 10.10 m/s
Stack Diameter : 0.2 m
Stack Effluent Temp. : 20.0 deg C
Air Temperature : 20.0 deg C
Effective Release Height : 6.40 m
Wind Speed (h=10 m) : 3.84 m/s
Distance Coordinates : All distances are on the Plume Centerline
Wind Speed (h=H-eff) : 3.72 m/s
Stability Class : B
Respirable Dep. Vel. : 0.30 cm/s
Non-respirable Dep. Vel. : 8.00 cm/s
Receptor Height : 1.5 m
Inversion Layer Height : None
Sample Time : 10.000 min
Breathing Rate : 3.33E-04 m3/sec

Maximum Dose Distance : 0.034 km
MAXIMUM TEDE : 7.41E-03 rem



e. USGS SAR Section 11.1.1.1.4 discusses the estimation of offsite doses from routine releases of Ar-41. Please provide a reference and justification for the use of Equation 11.31 for estimating ground level concentrations of Ar-41 including the basis for the average air concentration during operations of 5.85×10^{-6} μCi per cubic meter. Please provide an evaluation of your analysis to meeting the regulatory limit cited in 10 CFR 20, Appendix B in units of μCi/mL, and an estimate of the dose to a member of the public.

This response will not use Equation 11.31 nor the method presented in the submitted SAR for evaluation of Ar-41 emissions, but will use the DOE HOTSPOT computer code instead. Because of the small reactor bay volume at the GSTR, our Ar-41 concentrations in the bay (and in the effluent air) are higher than at a more typical TRIGA facility. That is why we have a Technical Specification that states, "The concentration of argon 41 in the reactor building stack effluent air shall be limited to a maximum of 4.8×10^{-6} μCi/ml averaged over a year." This allowance is higher than the 10CFR 20 Appendix B value of 1×10^{-8} μCi/ml, but the following analysis will show that our Ar-41 releases do not present a hazard to the public. We will need a similar Technical Specification limit in our new license.

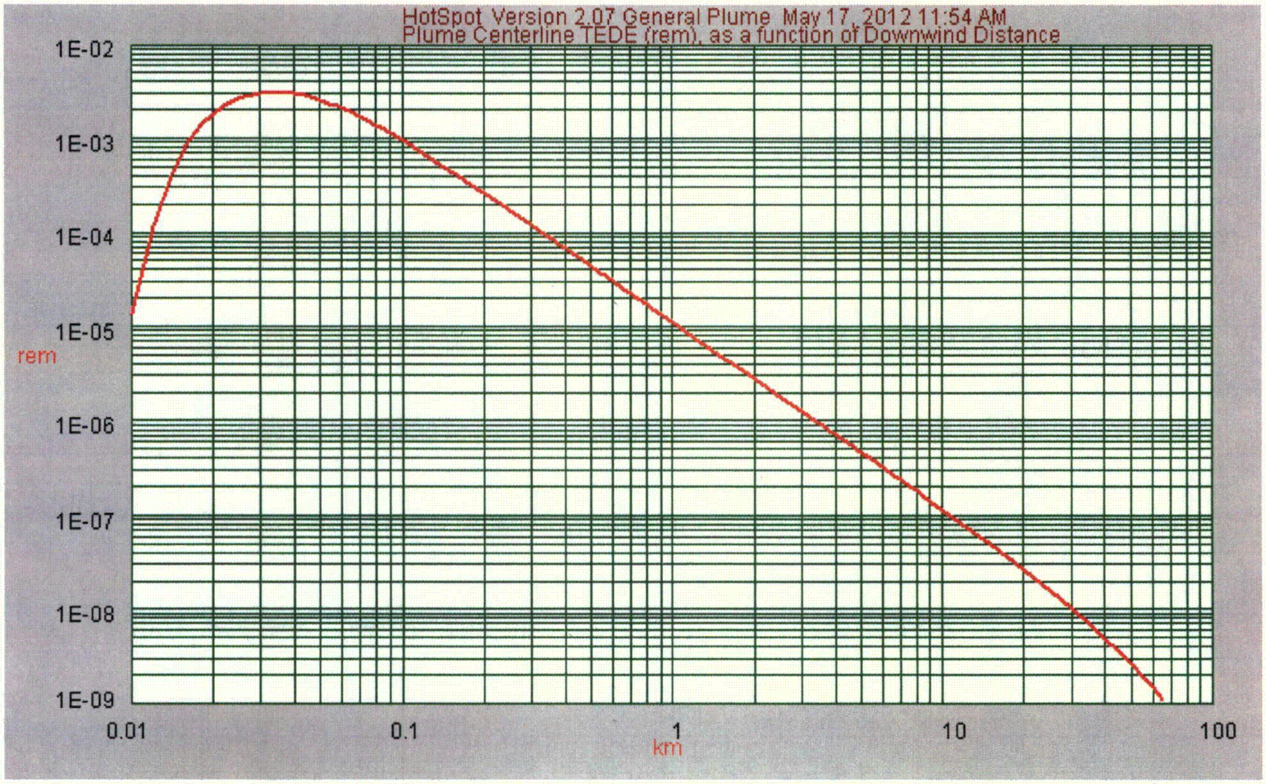
The evaluation of the Ar-41 dose estimate to the public was recalculated using the DOE HOTSPOT computer code (version 2.07), general plume model. A nominal exhaust flow of 3.17×10^{5} ml/s along with a full power reactor exhaust air concentration of 4.35×10^{-6} μCi/ml results in 1.38 μCi/s released during full power operation. Conservatively assuming 1560 hours of operation a year (6 hours a day and 5 days a week) at full power results in a total release of 7.75 Ci of Ar-41 for the year.

The nearest unrestricted public access point is 350 meters from the Ar-41 release point and the nearest public residence is 640 meters from the release point. The HOTSPOT results are given below, showing input parameters and a graph of the dose versus downwind location. The dose at a distance of 350 meters downwind of the release point is 0.067 mRem and the dose at a distance of 640 meters downwind of the release point is 0.020 mRem. These annual doses are far below any NRC limits for members of the public.

HotSpot Version 2.07 General Plume

May 17, 2012 12:33 PM
Source Material : Ar-41 1.827h
Material at Risk : 7.7500E+00 Ci
Damage Ratio : 1.000
Leakpath Factor : 1.000
Airborne Fraction : 1.000
Respirable Fraction : 1.000
Respirable Release Fraction: 1.000
Physical Stack Height : 6.4 m
Stack Exit Velocity : 10.10 m/s
Stack Diameter : 0.2 m
Stack Effluent Temp. : 20.0 deg C
Air Temperature : 20.0 deg C
Effective Release Height : 6.40 m
Wind Speed (h=10 m) : 3.84 m/s
Distance Coordinates : All distances are on the Plume Centerline
Wind Speed (h=H-eff) : 3.72 m/s
Stability Class : B
Respirable Dep. Vel. : 0.30 cm/s
Non-respirable Dep. Vel. : 8.00 cm/s
Receptor Height : 1.5 m
Inversion Layer Height : None
Sample Time : 10.000 min
Breathing Rate : 3.33E-04 m3/sec
FGR-11 Dose Conversion Data - Total Effective Dose Equivalent (TEDE)

DISTANCE km	T E D E (rem)
0.350	6.7E-05
0.640	2.0E-05



Here is the response to question 27:

27. NUREG-1537, Part 1, Section 11.2.3, "Release of Radioactive Waste," requests that the licensee provide a description of all radioactive waste released to the environment, and a description of the controls in place to ensure that any liquid releases to the sanitary sewerage meet the requirements of 10 CFR 20.2003. USGS SAR Section 11.2.4 states that the licensee's policy is not to normally release radioactive liquid waste. However, this statement does not prevent the potential release of radioactive liquid waste. Please provide a description of any potential radioactive liquid waste releases to the environment, and the controls in place to help ensure that any radioactive liquid releases meet the requirements of 10 CFR 20.2003.

It is the GSTR's policy not to routinely release radioactive liquid waste. Normal operations of the GSTR do not produce liquid radioactive waste. The occasional liquid radioactive waste that is produced at the GSTR would be irradiated samples, liquid standards, decontamination waste, and reactor tank water. None of these items are disposed of as a liquid. The liquid waste is mixed with cement or evaporated in a controlled fume hood until it is a solid and then disposed of by a licensed waste disposal broker in accordance with the governing regulations.

When it is necessary to dispose of large quantities of liquid radioactive material, and solidification with cement or evaporation is not a reasonable option, then the material will be characterized and verified to be within 10 CFR 20 limits. The governing body of the sewer system (currently Denver's Waste Water Management Division) is contacted and acceptance of disposal in the sanitary sewer is verified. This process has happened one time in the history of the facility, when the reactor tank was drained in 1988 in order to install a tank liner. There are no future plans to dispose of a large quantity of liquid radioactive waste.

Currently at the GSTR there is no direct path for radioactive liquid waste to reach the sanitary sewer. Radioactive liquid waste is handled in controlled areas and contained in separate containers. Human interaction would be required for waste to reach the sanitary sewer.

Sincerely,

Tim DeBey

Tim DeBey

USGS Reactor Supervisor

I declare under penalty of perjury that the foregoing is true and correct.
Executed on 5/18/12

Copy to:

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