50-186

UNIVERSITY OF MISSOURI

Research Reactor Facility

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March 16, 1979

Director of Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Dominic DiAnni

Reference:
1. Docket 50-186
2. University of Missouri Research Reactor (MURR) License R-103
3. MURR request letter of February 15, 1977
4. Letter of questions USNRC to MURR dated August 4, 1977
5. MURR response to NRC questions dated September 23, 1977
6. MURR response to NRC questions dated March 27, 1978
7. Phone conversation of January 28, 1979, J. Schlapper et al., of MURR to D. DiAnni et al., of USNRC
8. Phone conversation of February 27, 1979, J. Schlapper of MURR to D. DiAnni and J. Donahue of USNRC.

As requested in the referenced conversations with U.S.N.R.C. the University of Missouri Research Reactor Facility (MURR) submits the following supporting information.

1. With respect to the request for additional site monitoring, the MURR proposes that TLD monitoring stations be placed as follows.

   a. Four stations located on north, south, east, and west walls of the laboratory building.

   b. Four stations located at a distance of approximately 150 meters from the reactor building. One of these stations will be placed in the direction of prevailing wind. The remaining stations will be placed at locations 90°, 180°, and 270° from the first station.

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c. Other stations will be placed at buildings in the Research Park area. At a minimum, one station will be installed at the Dalton Research Center.

d. One station will be placed on University property close to the nearest public residence.

The MURR proposes to accumulate data for a period of one year. This information will be forwarded to U.S.N.R.C. at that time. Continuation of the monitoring program will be based on the annual results.

2. With respect to the request of U.S.N.R.C. to provide a calculation of total annual dose at the nearest public residence, the MURR supplies the following information. Calculations are based on the following references and assumptions.

a. References

1. U. S. Nuclear Regulatory Guide 1.109 dated March 1976 (as submitted for comment).

2. Gifford, F., and Waterfield, R., "Simplified Atmospheric Diffusion Calculations with Slide Rule Gage Points," Proceedings of the U.S.A.E.C. Meterological Information Meeting, AECL-2787, September 1967, pp. 132-136.

3. Meterology and Atomic Energy, Appendix A, 1968.

4. Rupp, A. F. et al., "Dilution of Stack Gases in Cross-Winds," U.S.A.E.C. Report AECD-1811, p. 1-15, 1948.

5. Hilsmeier and Gifford (1962) as presented in Figure A.5 of Appendix A-2, Meterology and Atomic Energy, 1968, p. 411.

b. Assumptions

1. Wind speed is assumed to be the average for the reactor site as measured during past years of reactor operation, U = 2.2 m/sec.

2. Stack height employed as assumed to be the "effective" stack heights as calculated using equations in reference 4 and the following data.

Height of stack = 17.4 meters

Exit velocity = 14.7 m/sec (as measured)

Average site wind velocity = 2.2 m/sec

Diameter of stack = 1 meter

$\Delta h = 1.5 \frac{u_s}{u} d = 10.0$ meter

Effective stack height = 17.4 + 10.0 = 27.4 meters.

3. For purposes of dose calculation, the releases are assumed to be ground level releases.

4. Release rate of the nuclide Ar-41 of 1800 Ci/year is based on current data for 10 MW operation, 365 days/year on an 89.7% duty cycle (150 hours/week).

5. No decay of Ar-41 is assumed during diffusion.

6. Approximate distance to nearest residence is 760 meters based on aerial photograph measurement.

c. Calculation of Average Annual Ground Level Concentration of Ar-41

From Equation B-4 of Regulatory Guide 1.109, the average annual ground level of Ar-41 in the plume is calculated.

$$\chi_{41}(r,0) = 3.17 \times 10^4 \, Q^*_{41} \, [\chi/Q]^D (r,0)$$

where

$\chi_{41}(r,0)$ = Annual average ground level concentration of Ar-41 at the distance r in sector θ (pCi/m^3).

Q^*_{41} = Release rate of Ar-41 in Ci/year

$[\chi/Q]^D$ = Annual average gaseous dispersion factor.

The annual average gaseous dispersion factor of 8.2×10^{-5} is obtained from Figure 1 of the Gifford and Waterfield reference. The factor stated above is the maximum value for an effective stack height of approximately 30 meters and an average wind speed of 2.2 m/sec. This figure indicates that the maximum value occurs at a distance of 150 to 200 meters from the stack. For these conditions the value of $\chi_{41}(760m,0)$ is equal to 4.68×10^{-3} pCi/m^3.

d. Calculation of Total Body and Skin Doses due to Ar-41

Knowing the plume concentration, the total body and skin doses due to Ar-41 release can be calculated for personnel occupying the nearest residence assuming the residence is always in the plume. Equations B-8 and B-9 of Regulatory Guide 1.109 are employed.

Total Body Dose (Ground Level Release)

$$D_{\infty}^{T}(r,\theta) = 1.11\, S_f\, \chi_{41}(r,\theta)\, DFB_{41} \qquad (B\text{-}8)$$

where

$D_{\infty}^{T}(r,\theta)$ = Annual total body dose due to immersion in a semi-infinite cloud (mrem/yr).

S_f = Attenuation factor that accounts for dose reduction due to shielding provided by residential structures (assumed to be 0.7).

DFB_{41} = Total body dose factor for Ar-41 (from Table B-1 of Appendix B of Regulatory Guide 1.109, this quantity equals 8.84×10^{-3}).

Calculated annual total body dose = 32.2 mrem/yr at nearest residence, if the residence was always in the plume.

Skin Dose (Ground Level Release)

$$D_{\infty}^{S}(r,\theta) = 1.11\, S_f\, \chi_{41}(r,\theta)\, DF_{41} + \chi_{41}(r,\theta)\, DFS_{41} \qquad (B\text{-}9)$$

where

$D_{\infty}^{S}(r,\theta)$ = Annual skin dose due to immersion in semi-infinite cloud in sector θ at distance r from the release point (mrem/yr).

DF_{41} = Dose factor for Ar-41 from Regulatory Guide 1.109 in mrad per year/pCi per m^3 and is equal to 3.28×10^{-3}.

DSF_{41} = Beta skin dose factor for Ar-41 from Table B-1 of Regulatory Guide 1.109 and is equal to 2.69×10^{-3}.

Calculated total annual skin dose = 24.5 mrem/yr at nearest residence, if the residence was always in the plume.

The preceding calculations for total body and skin doses were made with the assumption that the residence was always located within the plume. To more realistically reflect actual conditions, the calculated exposures should be reduced by a factor which considers the approximate isotopic wind directions which our facility experiences. This factor is equal to the arc of the plume at the residence divided by 2π radians.

For the plume to disperse by a factor of 8.2×10^{-5} implies the cross sectional area of the plume at 760 meters has increased by a factor of 1.22×10^{4}, therefore, the diameter of the plume has increased from 1 meter to 110 meters. With the plume at 760 meters having an arc of 110/760 = 0.145 radians and with isotopic wind direction, then the residence would be in the plume 0.145/2π = 2.3% of the time.

Calculated annual total body dose =

32.2 mrem/yr x .023 = 0.74 mrem/yr at nearest residence assuming isotopic wind direction.

Calculated total annual skin dose =

24.5 mrem/yr x .023 = 0.56 mrem/yr at nearest residence assuming isotopic wind direction.

To calculate exposure of onsite personnel, Figure A.5 of the Hilsmeier and Gifford reference is employed. Maximum χ/Q for a 30 meter stack and 2.2 m/sec wind speed is employed. The value for χ_{41} with this data is 4.68×10^{3} pCi/m^3. Based on 1/3 occupancy time, the following doses are calculated.

Total Annual Body Dose - On-Site Personnel — 10.7 mrem/year

Total Annual Skin Dose - On-Site Personnel — 8.2 mrem/year

e. Environmental Sampling Data

In support of this calculated data, the MURR supplies the following data from our environmental monitoring program. This data was taken at various times and is based on a minimum of five samples at each location. Figure 1 details the location of the first group of samples from the stack discharge. Results of analysis for Ar-41 concentration are:

Point Number	Ar-41 Concentration (μCi/ml)
13	9×10^{-6}
14	4.7×10^{-6}
15	3.1×10^{-6}
16	2.1×10^{-7}

Data was taken downwind of the stack on a day with normal wind conditions but the wind speed was not measured. Along with this group of measurements, samples were obtained at the side of the laboratory building downwind of the stack at roof level. This sample area is approximately 23 meters below and downwind of the stack. Results of replicate samples at these locations indicated an Argon-41 concentration of 2×10^{-8} μCi/ml. Counting system sensitivity for Ar-41 during this series of measurements was determined to be 1×10^{-8} μCi/ml.

Following the conversation with U.S.N.R.C. of February 27, 1979, additional measurements were made. For this measurement, counting system, sensitivity for Ar-41 was measured to be 4×10^{-9} μCi/ml. Four groups of samples were obtained in the north, south, east, and west directions at a distance of approximately 150 meters from the stack. Results of multiple samples at each site indicated that the concentration of Argon-41 was not detectable. The Ar-41 concentration was less than the system detectable level of 4×10^{-9} μCi/ml. In addition to these measurements, an air sample was obtained at a location about one-half the distance and in the direction of the nearest residence. Results for this measurement also indicated levels of "less than detectable"; i.e., concentration of Ar-41 $< 4 \times 10^{-9}$ μCi/ml. Thus, the chosen models for stack discharge and subsequent dispersion possess a reasonable degree of conservatism.

Sincerely,

J. Charles McKibben
Reactor Manager

JCM:vs

Enclosure

Reviewed and Approved by:

Robert M. Brugger
Director