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May 13, 1994

Director of Nuclear Reactor Regulation
ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Mail Station P1-137
Washington, DC 20555

REFERENCE: Docket 50-186
University of Missouri Research Reactor
License R-103

SUBJECT: Response to Request for Additional Information dated April 20, 1994

The University of Missouri Research Reactor (MURR) provides the following responses to the Nuclear Regulatory Commission letter of April 20, 1994, requesting additional information required to evaluate our license amendment application dated March 28, 1994.

The four requests for information and our responses are attached. If you have any questions concerning our responses, please contact me at (314) 882-5203 or Charlie McKibben at (314) 882-5204.

Sincerely,

Walt A. Meyer Jr.
Reactor Manager

J. Charles McKibben
Associate Director

Christine M. Forante 5/13/94
CHRISTINE M. FORANTE
NOTARY PUBLIC STATE OF MISSOURI
BOONE COUNTY
MY COMMISSION EXP. APR. 14, 1995

bjb

attachment

Response to NRC Request for Additional Information dated April 20, 1994

1. *Your proposed wording for paragraph 2.B.(2)(a) of Amended Facility License No. R-103 reads in part:*

    The limit for possession, receipt, and use of contained uranium-235 is temporarily increased until . . .

    Paragraph 2.B.(2)(a) of Amended Facility License No. R-103 reads in part:

    The limit for possession, receipt, and use of contained uranium-235 of any enrichment is temporarily increased, until . . .

    Please justify the additional changes you are proposing or amend your proposed wording to correspond with your license.

We amend our proposed wording in paragraph 2.B.(2)(a) of amended facility license R-103 to include the phrase ". . . contained uranium-235 of any enrichment is . . . ." The omission of this phrase was an error in our March 28, 1994, amendment request.

2. *On your graph that shows projected U-235 possession, a note states that fuel usage at MURR has increased from 24 to 26 elements per year. Please explain this increase in fuel usage.*

The note referred to on our graph of projected U-235 possession states ". . . that MURR requires 26 fuel elements per year vs. the previous 24 per year." This means MURR will request 26 elements per year from the Department of Energy (DOE) starting in January 1995. This change will allow us more flexibility in making mixed core loadings for our weekly operations. There will actually be no increase in uranium burnup, only lower burnup per element.

For the past fifteen years, MURR has operated on a schedule of 10 MW operation for about 90% of all available hours per year. This results in fuel burnup of 3300 megawatt days (MWD) per year ($365 \times 10 \times 0.90 \simeq 3300$). This corresponds to 4160 grams of U-235 burned up per year.

MURR operates on a weekly cycle, with each core typically being operated for about 6.5 days. We attempt to load cores so that the control blades are almost fully withdrawn at the end of the week. This practice allows each fuel element to reach its maximum burnup at retirement.

Until several years ago we were able to start each week's operation with cores whose total burnup was 600 MWD. This allowed each fuel element to reach an average burnup of about 145 MWD. For a 3300 MWD per year operation, this required at least 23 elements per year ($3300 \div 145 = 22.8$ elements/year).

In the past several years MURR has increased the amount of neutron absorbing materials in the graphite reflector and the flux trap. To compensate for this negative reactivity we have had to progressively decrease the initial core burnup. We now use cores with 500 MWD to start each week and are able to reach only an average burnup of 130 MWD per element instead of the 145 MWD per element in the past.

Fuel management has been difficult the last few years with fewer than the optimal number of fuel elements in cycle. We have had to use more cores that were not initially Xe free as we prefer (i.e., two elements from the previous core are used in a new week's core). We now project that our future needs will be 26 elements per year (3300 ÷ 130 = 25.4 elements/year). The fuel (uranium) burnup per year at MURR remains the same, 4160 grams U-235 per year. Because of our need for additional positive reactivity (lower initial burnup) in our weekly cores, we need to slightly increase the number of fuel elements we use each year.

3. *Your amendment request states that the changes you are requesting will not require changes to the Physical Security Plan. Please confirm that a sufficient amount of stored fuel will remain self protecting for the possession extension period to meet the requirements of your Physical Security Plan.*

Our Physical Security Plan allows possession of up to 5 kg of unirradiated SNM. In practice this means we may not possess more than six 775 g U-235 unirradiated fuel elements. After an element has been irradiated in-core at 10 MW for a week, it remains self-protecting for over ten years. This is based on radiation dose measurements made here several years ago on an original MURR element with 5 MWD operating history and over ten years decay. Once used in core, all of our stored fuel will remain self-protecting well beyond the 2-3 year period it will be on-site before we expect to ship spent fuel again.

4. *Your amendment request states that the criticality aspects of fuel storage at MURR are not changed by the request. Please provide a discussion of storage racks, k-effective, and stored fuel cooling for the maximum amount of fuel that will be in storage during the period of the proposed increased possession extension.*

The MURR currently has 60 fuel elements at various levels of burnup. By May 31, 1995, the projected number of elements at MURR would reach 90 elements.

The attached diagram shows the fuel storage baskets in the MURR pool. Using the KENO code, we calculated $k_{eff} = 0.75$ for the baskets X, Y, MX, MY, O, fully loaded with new 775 gram U-235 elements. This is conservative, since elements stored in these baskets always have some burnup and are less than 775 g U-235. Similar calculations have shown that k_{eff} for the fully loaded Z baskets is less than 0.8. These in-pool storage locations are capable of storing 92 fuel elements.

Stored fuel cooling is not a problem in our pool because of the rapid decay of most fission products. We will use the methodology in Glasstone-Sesonske, Nuclear Reactor Engineering, Third edition, pp. 122-125 to show that fission product decay heat power for elements stored at MURR beyond one year after retirement from the fuel cycle does not represent a significant increment to required cooling capacity.

Figure 2.33 can be used to calculate the decay heat power at various times after shutdown following continuous reactor operation. MURR operates on a weekly cycle of 6.5 days at 10 MW followed by 0.5 days shutdown for maintenance and surveillance. This would be equivalent to continuous operation at 9 MW. For the following examples, we will calculate the typical decay power at various times after shutdown for the fuel elements in cycle for continuous operation at 10 MW.

The Glasstone-Sesonske graph (Figure 2.33) along with Table 2.13 and Equation 2.66 (derived from Figure 2.33) provide the following:

Decay Heat Power After Shutdown

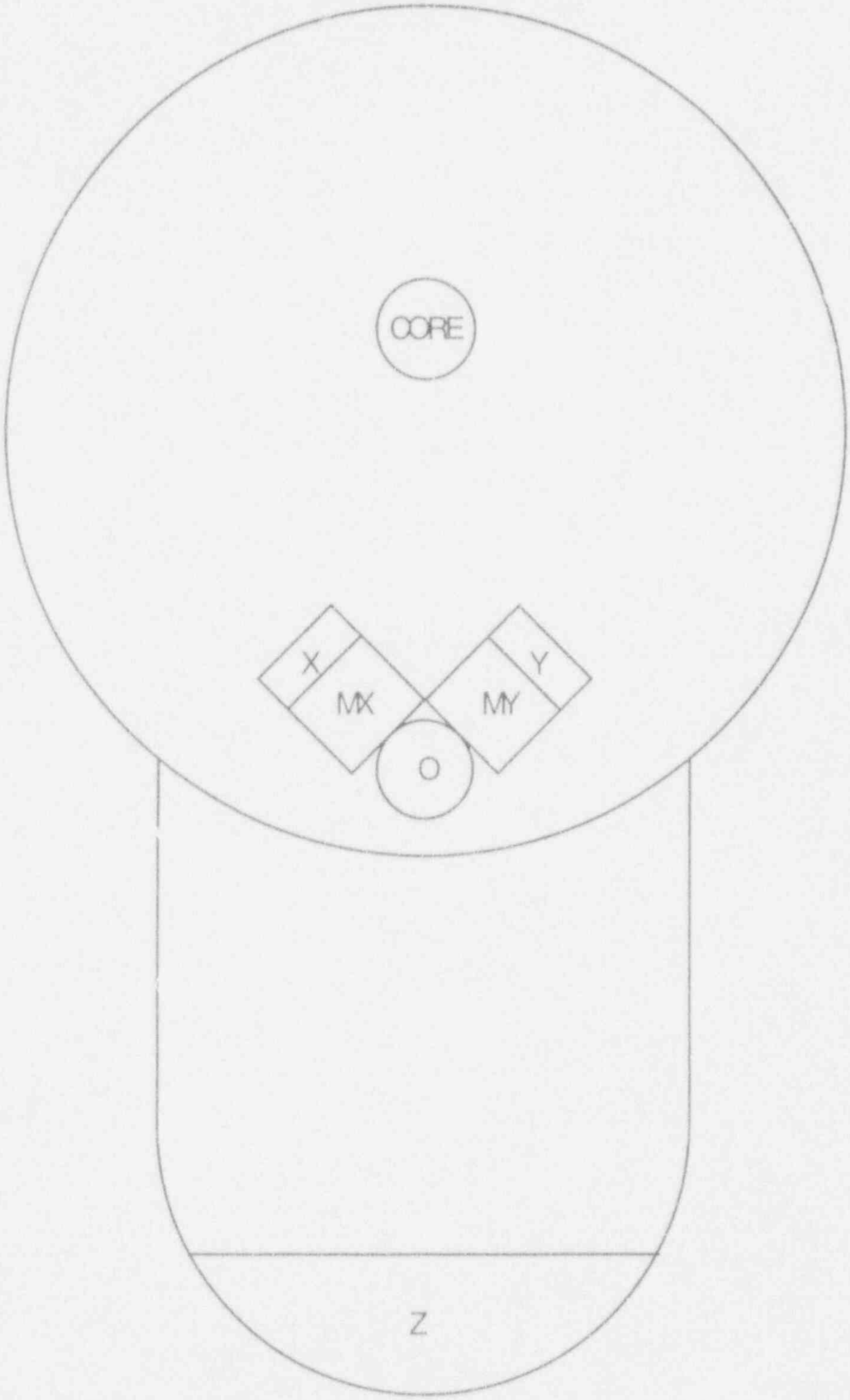
	Time After Shutdown (Cooling Period)				
Operating Time	1 minute	1 day	1 week	1 year	2 years
1 year continuous at 10 MW	360 kW	48 kW	19 kW	1.5 kW	0.8 kW
	from Table 2.13	from Table 2.13	from Equation 2.66	from Equation 2.66	from Equation 2.66

The total pool cooling system circulating water volume of greater than 28,000 gallons (20,000 gallon capacity pool) easily removes the decay heat at shutdown of our actual weekly operating cycle. The table above demonstrates that stored spent fuel generates negligible heat compared to the decay heat of fuel elements in cycle.

An additional 18 fuel elements can be temporarily stored safely in the National Lead Co. cask. Only fuel elements with more than 150 days decay after final in-core irradiation may be stored in the National Lead Co. cask on the beamport floor in containment. Calculations indicate and 1/M measurements during loading have verified that cask loadings have k_{eff} less than 0.8. The maximum decay heat of the fuel (18 elements at 150 days decay) is about 50% of the cask allowable heat load of 5.4 kW. In practice, elements stored in the cask have much greater than 150 days decay. The cask temperature is monitored to confirm the decay heat load.

MURR
Pool and Weir

SCALE: 1/2" = 1'-0"



Fuel Basket

Z	48 Elements
MX, MY	12 Elements each
X, Y	6 Elements each
O	8 Elements