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US Nuclear Regulatory Commission
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Rockville, MD 20852

Attn: Ms. Cindy Montgomery, Research & Test Reactors (NRR/DPR/PRLB), Mailstop O12 D20

SUBJECT: PURDUE UNIVERSITY - REQUEST FOR ADDITIONAL INFORMATION REGARDING THE PURDUE UNIVERSITY REACTOR LICENSE RENEWAL (TAC NO. ME 1594), RESPONSES TO RAIs (ML103400115 and ML103400250)

Dear Ms. Montgomery:

Enclosed please find the responses to the Request for Additional Information regarding the Purdue University Reactor License Renewal dated 6 July 2011. Included with this submission are responses to questions 54, 69, 77, 78, and 92. Should you have any questions or require further information, please don't hesitate to call me at 765.496.3573, or e-mail at jere@purdue.edu.

I hereby certify under penalty of perjury with my signature below that the information contained in this submission is true and correct to the best of my knowledge.

Very respectfully,

/SA

Jere H. Jenkins
Director of Radiation Laboratories

Attachments: As described.

Cc: Duane Hardesty, USNRC Project Manager for PUR-1
Leah Jamieson; Purdue University College of Engineering
Jim Schweitzer, Purdue University REM, CORO Chair
Ahmed Hassanein, Purdue NE

REQUESTED ADDITIONAL INFORMATION IN RESPONSE TO RAIs

REGARDING THE PURDUE UNIVERSITY REACTOR LICENSE RENEWAL (TAC NO. ME 1594)

54 NUREG-1537, Part 1, Section 10 provides guidance for providing information on the administrative procedures used by the applicant to approve an experiment. These procedures should be discussed in detail in Chapter 10 of the SAR, summarized in Chapter 12, "Conduct of Operations," and included in the technical specifications. Please provide the experiment review and approval methodology and discuss the experiment review and approval process.

Response:

The present review and approval process as described in the PUR-1 operations manual is as follows:

> A "Request for Reactor Operation" form will be prepared and submitted before any reactor operation is performed. This form, properly filled in, will state the purpose, procedure, apparatus, intended power level, reactor conditions, and expected results of the experiment, with supporting reasons. The Reactor Supervisor will review the request and consult members of the scientific staff if needed to establish the type of experiment. The Reactor Supervisor will decide upon the safety of a proposed experiment unless review by the Reactor Operations Committee is requested. Upon satisfactory completion of review of a proposed experiment, the Reactor Supervisor will schedule a time for its performance. Each "Request for Operation" form will be signed by the experimenter and, when required, countersigned by the staff member advisor. After the form is reviewed and approved, it is checked for necessary signatures, and posted in the control room.

Since procedures are subject to changes with appropriate review and approval, we do not feel that discussion in detail of procedures is appropriate in the SAR; only an overview should be provided, otherwise a procedure change would require a change in the SAR with each revision. New experiments are reviewed by reactor staff to ensure the safety of the reactor, staff and experimenters, and the public and environment. Experiments are also reviewed against the PUR-1 technical specifications to ensure operations within appropriate limits.

69. The requirements of 10 CFR 20.1201 include limiting the total dose equivalent to facility staff and the public from licensed reactor operations. In Section 5.6 of the SAR, it states that no nitrogen-16 activity has been observed to date in the reactor room. This referenced observation is known to be at a power level of 1 kW, based on previous licensed power for PUR-1. Please provide an updated evaluation of a bounding safety analysis that explains all analyses, assumptions, and conclusions at the requested licensed power level for the maximum potential release of N-16 from the pool water into the reactor room and any potential dose to the facility staff and members of the public (i.e., classrooms, hallways, adjacent rooms, nearest dormitories, offices, etc.).

Response:

There is a negligible fast neutron flux in PUR-1, which is required for the production of N-16 via the $^{16}O(n,p)^{16}N$ reaction, even at the new requested power. However, in the unlikely event that N-16 is produced, using a NATCON analysis at 18 kW power (which is higher than the 12 kW requested licensed power level, but is assumed to be an enveloping calculation), the maximum flow rate at the outlet of the hot channel is 0.00686 kg/s, at a velocity of 19.2 mm/s. Assuming an extremely conservative straight-line path of travel of a unit-volume of coolant water containing N-16, it would take approximately 206 seconds for that unit-volume to reach the surface of the pool, or approximately 28 half-lives for the produced N-16 (7.13 s). Thus, any credible assumed quantity of N-16 produced will have long since decayed before reaching the surface of the pool.

77. NUREG 1 537, Part 2, Chapter 13 s tates credible accide nts should be c ategorized a nd th e most limiting ac cident in ea ch gr oup should be analy zed in detail inclu ding th e po tential consequences of the v arious accid ent sc enarios including loss-of-coola nt ac cident (LOCA) events.

A. Pleas e p rovide an evaluation o f a s afety a nalysis o f the L OCA accident s equence assuming the maximum licensed power level including uncertainty resulting from power level measurement uncertainty.

B. Please p rovide an e valuation o f a safe ty a nalysis for safe cooling of the fuel during complete lo ss o f coolant e vent at the pe ak fuel pow er densities fo r th e maxi mum requested licensed power level.

C. Please provide an evaluation of a safety analysis for the slow draining process, which may result in a partially uncovered core (partial LOCA), that may not be cooled by assuming a continuous circulation of air. Please discu ss a partial LO CA sc enario and indicate whether the fuel temperature in a partially uncovered core is still bounded by the SAR LOCA analysis.

<u>Response:</u>

We feel that this question is unreasonable. As written in Section 13.1.3 of NUREG 1537, “In many non-power reactor designs, the loss-of-coolant accident (LOCA) is of no consequence because decay heat in the fuel is so small as to be incapable of causing fuel failure.” NUREG 1537 goes on to describe that in some higher power reactors (normally greater than 2 MW), some engineered safety feathers for emergency core cooling may be necessary. The requested power uprate to 12 kW is 166 times smaller than the 2 MW threshold suggested by NUREG 1537 where fuel damage as a result of a LOCA is possible.

The reactor pool is designed to prevent unintentional drainage. The pool is constructed of a stainless steel liner and set in a second steel tank with the interstitial region filled with sand. The tank rests on a concrete pad about 4.6 m below the floor of the reactor room, which is in the basement of the building. The pool has no drains or coolant pipes below floor level (more than 8 feet above the core) that could open or break. Therefore, a sudden loss of coolant is considered to be extremely unlikely. Furthermore, if the pool drained instantaneously while the reactor was operating, the loss of water (moderator) would shut down the reactor.

Even if the worst case is assumed, and PUR-1 experiences a LOCA, utilizing the Way-Wigner [1] equation for fractional power resulting from core decay heat:

$$\frac{P}{P_o} = 6.22 \times 10^{-2} \left[t^{-0.2} - (T_i + t)^{-0.2} \right] \quad (1)$$

where

P	=	Core power after shutdown
P_o	=	Power generated during operation
t	=	Time in seconds after shutdown, and
T_i	=	Time irradiated, or time at operating power.

Assuming an infinite time at a conservative operating power of 18 kW (50% above the requested 12 kW), the power generated in the reactor at 60 seconds after shutdown is 493 W, or an average of 2.6 W/plate for the 190 plates. Even using a conservative power peaking factor of 2 for the hot channel plate, applying that value of 5.2 W/plate to all plates in the reactor, and assuming adiabatic conditions (which would encompass all conceivable LOCA scenarios), there would not be significant enough heating to cause damage to the fuel plates in any credible scenario.

78. NUREG-1537, Part 1, Section 13.1.4 provides guidance for analysis of loss-of-coolant flow resulting from blocked fuel cooling channels.

A. Please provide an evaluation of a safety analysis that provides a complete assessment of the potential for fuel channel blockages and how adequate heat transfer during such blockages is maintained.

B. Please discuss facility procedures or any other blockage-mitigating PUR-1 design features for foreign material exclusion from entry to the reactor pool in order to prevent blockage of coolant channels.

Response:

NUREG 1537, Part 1, Section 13.1.4 provides guidance for analysis of loss-of-coolant flow as "most limiting for forced-convection non-power reactors, where the forced flow is downward through the reactor core." Since PUR-1 operates with only natural convection, there is no scenario to be considered for loss of forced flow. Using a NATCON analysis at 18 kW power (which is higher than the 12 kW requested licensed power level, but is assumed to be an enveloping calculation), the maximum flow rate at the inlet of the hot channel is 0.00686 kg/s, at a inlet velocity of 19.13 mm/s. In order for a channel to be blocked at the inlet, a buoyant item would have to find its way under the reactor deck fifteen feet below the surface of the pool. This is not a credible scenario. It is also not a credible scenario for any non-buoyant item that might find its way to the bottom of the pool to be drawn up from the bottom of the pool to block a channel due to the mass flow rate. Therefore, a loss-of-coolant flow accident is not a necessary consideration.

92. SAR, Section 13.2.1, makes reference to restricted and unrestricted areas. These types of areas are not defined in the SAR or emergency plan. Please update the SAR and/or emergency plan to use consistent designations or provide the definition of these areas and explanation of relationship to defined areas such as the operations boundary, site boundary, reactor building, or nuclear engineering lab.

Response:

There are no suggested definitions of 'restricted area' or 'unrestricted area' in NUREG 1537 or the ANSI/ANS 15.1, 15.16 or 15.21 standards, nor is there guidance that suggests they be provided. The use of 'restricted area' and 'unrestricted area' in the SAR, Section 13.2.1, is consistent with the Accident Analysis guidance in Chapter 13 of NUREG 1537, and is in accordance with 10 CFR 20. The definitions of 'restricted area' and 'unrestricted area' as presented in 10 CFR 20.1003 are as follows:

> *Restricted area* means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Unrestricted area means an area, access to which is neither limited nor controlled by the licensee.

It should be assumed that a ‘restricted area’ is wherever it needs to be defined as determined by reactor staff (as suggested in the Emergency Plan) where exposures to personnel or the public are possible as a result of an accident.

References

1. Etheringto n, H., *Nuclear engineering handbook*. 1st ed. McGraw-Hill handbooks. 1958, New York,: McGraw-Hill. 1 v. (various pagings).