

# Nuclear Reactor Laboratory

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December 8, 2010

RSC 1072

United States Nuclear Regulatory Commission  
ATTN: Document Control Desk  
Washington, D.C. 20555

Subject: Docket 50-156, License R-74  
Response to Request for Additional Information  
for License Renewal to Facility License No. R-74  
University Of Wisconsin Nuclear Reactor  
TAC No. ME1585 (Technical RAI)

Dear Sirs:

By letter, dated November 18, 2010, the Commission has requested additional information in order to complete the review for the University of Wisconsin Nuclear Reactor's (UWNR) request to renew facility license number R-74.

Enclosed are the responses to the request for additional information. The responses are provided in the same order as the Commission's requests. The format of the enclosure is to restate the request followed by the response. The original request is counter shaded to aid in the separation between request and response.

I certify under penalty of perjury that the foregoing is true and correct.

Sincerely,

Robert J. Agaise  
Reactor Director

Executed on: 12/8/2010

Enclosure

A020  
NRR

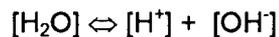
## UWNR Response to NRC Request for Additional Information

NRC RAI:

Proposed UWNR TS 3.3 contains limits on primary water conductivity but does not contain a limit on pH. NUREG-1537, Chapter 5, Reactor Coolant Systems, Section 5.2, Primary Coolant System, requests applicants to provide coolant quality requirements, including pH. Please explain why a limit on pH is not necessary to limit corrosion of fuel cladding and other materials in the reactor pool; or propose and justify a limit on pH.

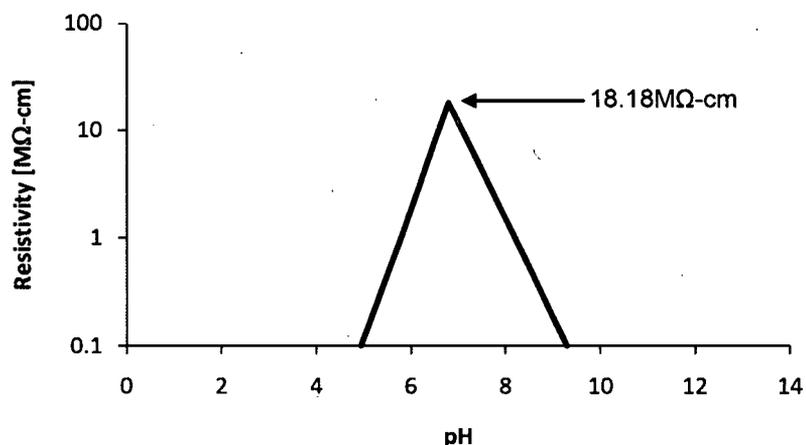
Licensee's Response:

The pH of water is defined as the negative logarithm of the hydrogen ion  $[H^+]$  concentration, or  $-\log_{10}[H^+]$ . In pure water a constant dissociation and recombination of the hydrogen ion  $[H^+]$  and hydroxyl ion  $[OH^-]$  occurs as shown in the equation below and is temperature dependent<sup>1</sup>.



At 25°C, the  $[H^+]$  concentration is  $1.004 \times 10^{-7}$  mol/L and therefore the resulting pH is 6.998. As a result it is challenging to measure the pH of pure water due to the near absence of ions that would enable electron transport between the measuring and reference sides of a pH electrode. Furthermore, adding the slightest amount of acid or base to pure water will change its pH significantly. As an example, pure water readily absorbs carbon dioxide ( $CO_2$ ) when exposed to atmosphere which forms carbonic acid,  $H_2CO_3$ , a weak acid. Even the absorption of fractions of a  $\mu\text{g}/\text{kg}$  (parts per billion, ppb) concentration will ultimately lead to a pH of approximately 5.8<sup>2</sup>.

A more accurate method of determining pure water quality is by measuring its conductance, or conversely, its resistance. Conductivity measures the flow of electrons through a fluid, which is proportional to the concentration of ions in the fluid. As noted above, in pure water at 25°C, the  $[H^+]$  concentration is  $1.004 \times 10^{-7}$  mol/L and therefore the resulting conductivity is 0.055 S/cm, or its resistivity is 18.18M $\Omega$ -cm. Therefore a measure of conductance or resistance can predict the absolute range of pH as shown in the figure below<sup>1</sup>. This method is also the method required for pure water quality measurements as promulgated by the International Organization for Standardization, ISO 3693:1987.



UWNR TS 3.3.3 contains a limit on primary water conductivity to be less than 5 micromhos/cm (note: 1 micromho is equal to 1 $\mu$ S) or in terms of the resistivity (the actual parameter measured) greater than 0.2 M $\Omega$ -cm. As a result the absolute possible range of pH would be between 5.58 and 8.42 which is consistent with the acceptance criteria of NUREG-1537, Part 2, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Standard Review Plan and Acceptance Criteria, section 5.2.

**References**

1. Light, T.S.; "Temperature Dependence and Measurement of Resistivity of Pure Water"; Analytical Chemistry, Vol. 56, No.7, p.1138-1142, June 1984.
2. Riche, E., Carrie, A., Andin, N., Mabic,S.; "High-Purity Water and pH"; American Laboratory News, June/July 2006.

**NRC RAI:**

Proposed UWNR TS 3.2.5 does not contain an interlock to prevent the withdrawal of multiple control elements at the same time. NUREG-1537, Chapter 13, Accident Analysis, Section 13.1.2, Insertion of Excess Reactivity, requests applicants to analyze ramp insertions of reactivity. Please analyze and discuss a reactivity addition event based on the withdrawal of the maximum number of control elements possible in accordance with your TSs. Please discuss the results of the analysis as compared against the safety limit for the reactor.

**Licensee's Response:**

Using the control element differential worth curves from the LEU Conversion SAR pages 42-44, the maximum differential worth of each control element was converted to units of % $\Delta$ k/k per minute by multiplying by the control element drive speed.

<b>Control Element</b>	<b>Maximum Differential Worth [%<math>\Delta</math>k/k / inch]</b>	<b>Drive Speed [in/min]</b>	<b>Reactivity Insertion Rate [%<math>\Delta</math>k/k / min]</b>
Blade 1	0.22	14.5	3.19
Blade 2	0.21	14.5	3.05
Blade 3	0.26	14.5	3.77
Regulating Blade	0.034	17.0	0.58
Transient Rod	0.27	28.0	7.56
<b>TOTAL</b>	<b>N/A</b>	<b>N/A</b>	<b>18.1</b>

The maximum total reactivity insertion rate is 18.1 % $\Delta$ k/k per minute, or 0.302 % $\Delta$ k/k per second. The RELAP5/MOD3.3 2-channel model from the LEU Conversion SAR was used to model this reactivity insertion rate starting with the reactor critical below the point of adding heat. The calculated core power exceeds 1.3MW at 3.36 seconds following the start of the ramp insertion, at which time the automatic power level scram would be initiated. For conservatism, the control elements are assumed to continue withdrawing at the maximum

reactivity insertion rate for an additional two seconds, which is the maximum allowable scram time, at which time they are instantaneously and fully inserted. The peak power of 24.0MW occurs at 3.49 seconds as seen in Figure 1, a full 1.87 seconds before the control elements even insert, due to the inherent large prompt negative fuel temperature coefficient of reactivity of TRIGA fuel. The peak fuel temperature of 434°C occurs at 5.36 seconds when the control blades are assumed to be fully inserted, as seen in Figure 2. The total energy release is 19.6MJ.

The peak fuel temperature and energy release during this event are less than the values of 663°C and 26.9MJ as calculated for routine pulsing following a step insertion of 1.4%  $\Delta k/k$  as shown in Table 4.7.22 on page 136 of the LEU Conversion SAR. Therefore the simultaneous withdrawal of all control elements is bounded by the routine pulsing analysis in section 4.7.10 of the LEU Conversion SAR and the analyzed rapid addition of reactivity accident postulated in section 13.2 of the LEU Conversion SAR of a step insertion of 1.4%  $\Delta k/k$  while operating at 1.3MW.

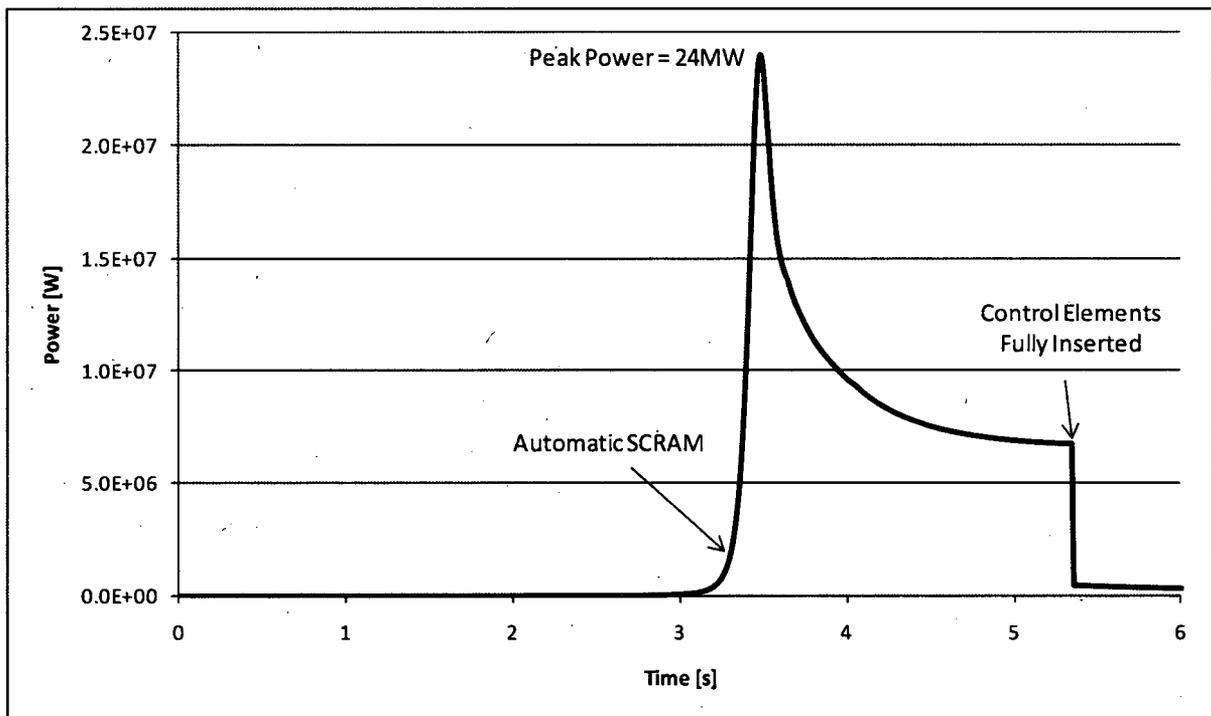


Figure 1, Power vs. Time during Simultaneous Control Element Withdrawal

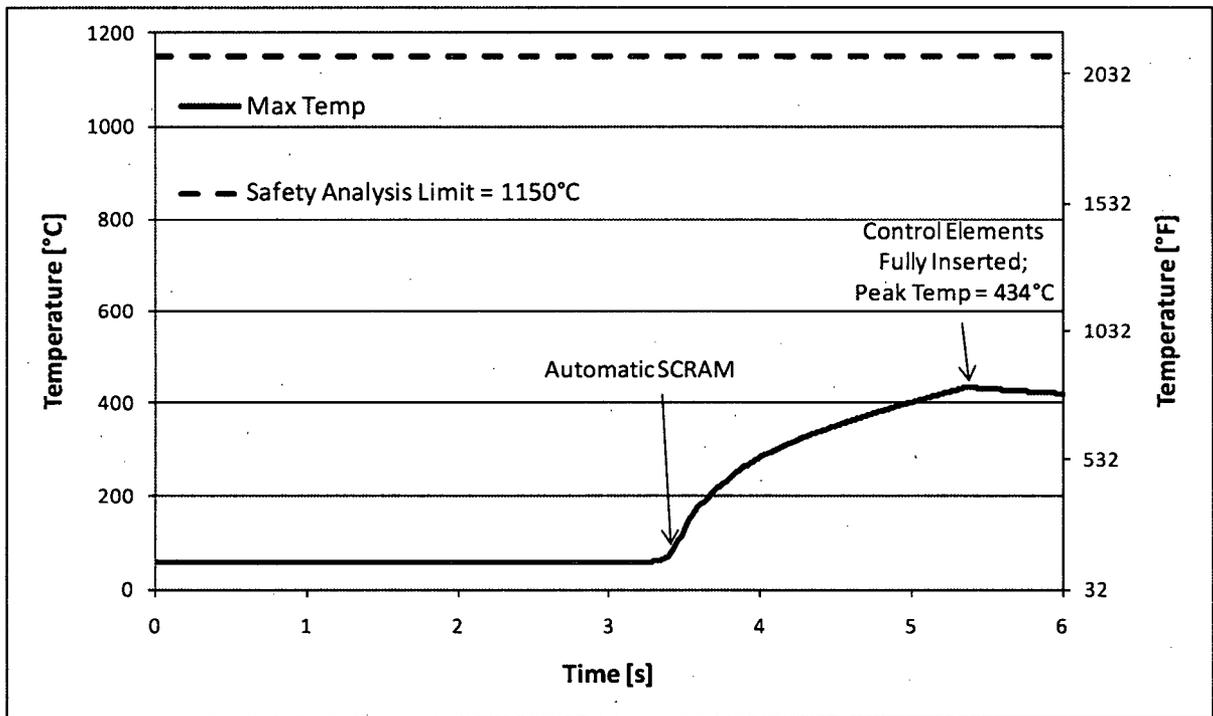


Figure 2, Maximum Fuel Temperature vs. Time during Simultaneous Control Element Withdrawal