Advanced LWR Program
UTILITY STEERING COMMITTEE

April 25, 1991

Document Control Desk
USNRC
Washington, D.C. 20555

Subject: Project 669 - Response to RAI on Chapters 4 and 7, Volume III of the Requirements Document

Reference: Letter from James H. Wilson to E. E. Kintner dated February 22, 1991

Gentlemen:

The enclosure contains written responses to the Request for Additional Information on Chapters 4 and 7, Volume III of the Requirements Document, concerning reactivity, physics, fuel and fuel storage criticality aspects.

Please call John D. Trotter at EPRI (415/855-2786) if you have any questions.

Very truly yours,

E. E. Kintner, Chairman
ALWR Utility Steering Committee

cc: J. H. Wilson
G. Bockhold
File 3.2

GB/L15/LDJ/SEO

EPRI Advanced LWR Program
3412 Hillview Avenue, Palo Alto, CA 94304 • Telefax: (415) 855-2774

Reference: NRC letter, E. E. Kintner, dated February 22, 1991

Chapter 4
NRC Question

440.1, Paragraph 2.2.4: Based on the large uncertainties which presently exist in predicting the stability of power reactors, how is assurance provided that the design objective is satisfied?

Response

It is recognized that prediction of BWR stability cannot be precise. To account for this, the ALWR policy is to provide defense in depth as described below:

a) the margin between the calculated stability and the stability decay ratio limit will be no less than 0.6 (see Requirement 4.2.1.2.1), and
b) the reactor will be equipped with instrumentation capable of detecting oscillations so that the reactor can be placed in a stable state before thermal limits are exceeded (see Requirement 4.2.1.2.2).

This policy, along with the results of the GE SBWR analysis demonstrating stability margins larger than 0.6 under both operating and transient conditions, were presented to the NRC on January 15, 1991. As documented in the NRC's meeting minutes dated 1/30/91, the staff agrees with the approach taken to date, and identified two open items that require additional analysis, to be done by GE.

NRC Question

440.2, Paragraph 2.2.5: EPRI should clarify what the 15 percent available margin for operations refers to. Also, explain Figure 4.2-1, Fuel Thermal Margin, in terms of a typical limit such as DNBR or LHR.

Response

The 15% operational margin refers to a demonstrated margin over and above routine margins for design transients, calculational uncertainties, measurement and set-point tolerances, etc. included in the design. The intent of the 15% operational margin is to assure that the reactor design is robust and can be reliably operated

without encroaching on operational limits. This margin would be available to the plant owner for use at his own discretion. It would be used to accommodate unexpected changes and thus avoid unnecessary plant operating restrictions. An example of an application of the operating-margin requirement to DNBR (Departure from Nucleate Boiling Ratio) is that DNBR must meet the following criterion at the time of minimum DNBR for the most limiting location in the core:

$$\text{minimum DNBR} \geq 1.15\ \text{DNBR}_{LL}$$

where DNBR_{LL} is the licensing limit for the DNBR correlation used when licensing the core design.

The difference between minimum DNBR and 1.15 DNBR_{LL} is the operating margin available to the plant owner. It corresponds to the available operating margin displayed in Figure 4.2-1.

NRC Question

440.3, Paragraph 2.2.6.1: EPRI should clarify whether this requires the reactivity control system to operate automatically or to be capable of insertion upon manual scram following an earthquake.

Response

The intent of paragraph 2.2.6.1 is to require the reactivity-control systems to perform their intended safety functions, not to define those safety functions. The safety functions required of the reactivity-control system for postulated events, including earthquake will be defined as part of the design process. If automatic or manual operation of the reactivity-control system during or after an earthquake is necessary to meet regulatory requirements, it would be identified as a safety function during the design process and paragraph 2.2.6.1 would apply. The last sentence of paragraph 2.2.6.1 is redundant to the remainder of the requirement. Accordingly, it will be deleted. The same change will be made in requirement 2.2.6.1 in Chapter 4 of Volume II.

Reference: NRC letter, E. E. Kintner, dated February 22, 1991

NRC Question

440.4, Paragraph 2.2.7: Shutdown margin requirements vary throughout core life. Usually, the most restrictive requirement occurs as a result of the steamline break analysis and is larger than the 1 percent discussed in this paragraph. EPRI should either modify the Requirements Document to include shutdown margin requirements for all operating modes or provide justification for not using a larger conservative value. In addition, the staff disagrees that reactivity accidents do not result in fuel damage since limited fuel damage generally does result from a control rod ejection accident in PWRs. (See Item 6 below.) EPRI should either modify the Requirements Document to reflect this position or provide additional justification for its position.

Response

The reactivity requirement in Section 2.2.7 refers to the net core reactivity (i.e., margin below criticality), not the required worth of the reactivity-control system. The actual total required worth will be a function of the details of the reactor-fuel and fuel-cycle designs employed in an ALWR. It is agreed that a steam-line break is probably the most restrictive requirement for accidents and that the total required worth would be greater than 1% reactivity. There is no intent to depart from current, NRC-approved practice regarding reactivity shutdown margin, including shutdown for a steam-line break. No change to the requirement is necessary.

The requirement related to the prohibitions on damage from reactivity accidents are not intended to make a blanket statement about the consequences of such accidents in all existing reactor designs. It is only intended to establish a utility design requirement for future LWRs. No change to the requirement is necessary.

NRC Question

440.5, Paragraph 2.2.8: Credit may be taken for borated water inside the reactor core during fuel handling but non-borated water must be assumed for fuel handling and storage outside of the core.

Reference: NRC letter, E. E. Kintner, dated February 22, 1991

In addition, although analyses are performed for PWRs to confirm that the refueling boron concentration is sufficient to maintain the required 5 percent shutdown margin for the final core configuration, these analyses may not be sufficient to assure that the shutdown margin will be maintained for all intermediate fuel assembly positions. Therefore, any intermediate fuel assembly configuration intended to be used during refueling must be identified and evaluated to assure that sufficient refueling boron concentration exists to maintain the 5 percent shutdown margin (NRC Bulletin 89-03).

Response

It is agreed that non-borated water must be assumed for fuel-handing and storage in the spent-fuel pool: this is an ALWR requirement; see Chapter 7. it is further agreed that intermediate (i.e., temporary) fuel configurations must be considered in planning refueling and that the intermediate configurations must remain within licensing limits on reactivity. The intent of paragraph 2.2.8 is to require a core design that can tolerate any single equipment failure or procedural error at any time during fuel-handling inside or outside the reactor core. Stated another way, a single equipment failure or procedural error must not result in a criticality accident. To emphasize the intermediate fuel configuration concern, the first sentence of paragraph 2.2.8 of both Volumes II and III, will be revised to read "...inside and outside the reactor core, including planned intermediate fuel configurations, for any single...".

NRC Question

440.6, Paragraph 2.3.3.1.1: Since this paragraph is apparently referring to LOCA only and not reactivity accidents, this should be stated. Most limiting reactivity accidents, such as the control rod ejection, usually do breach the cladding of some fuel.

Response

The requirement is generally directed at all design-basis events including, but not limited to, LOCA. For the ALWR, the utilities require that cladding not be breached

in a rod-ejection event. See paragraph 2.2.7 of Chapter 4. No change to this requirement is needed.

NRC Question

440.7, Paragraph 2.3.3.2: EPRI should specify additional criteria or limitations on the use of reconstituted fuel assemblies.

Response

The intent of paragraph 2.3.3.2 is to require that the mechanical design of the fuel permit reconstitution, as some existing designs currently do. The criteria and limitations on the use of reconstituted fuel will be those in use at the time of reconstitution. These are outside the scope of the Requirements Document. No change to this requirement is necessary.

NRC Question

440.8, Paragraph 4.2.4: The stated objective of a channel lifetime equivalent to two fuel bundle in-core residence times appears difficult to achieve at present. What criteria and analyses will be used to confirm the fuel channel lifetime objective can be attained?

Response

The objective has been demonstrated as feasible for selected channels built to suitably stringent requirements and operated under fuel management which accounts for channel irradiation effects. The criteria are the same as those presently used for BWR core evaluations, with proper accounting made for irradiation exposure effects on channels (e.g., bowing, corrosion, creep deformation). The decision on whether to use the two-bundle channel lifetime will be made by the individual utilities at the time of use. Those not electing to reuse channels would also benefit from the enhanced margin.

Chapter 7
NRC Question

440.9, Paragraph 2.2.2.2.1: The design requirement states that the spent fuel pool storage racks are designed for subcriticality with fresh fuel.

Reference: NRC letter, E. E. Kintner, dated February 22, 1991

However, for BWR fuel (and some PWR fuel designs) with embedded burnable poison, the most reactive time in life may not be beginning of cycle (fresh fuel). EPRI should either modify the Requirements Document to reflect this position or provide additional justification for EPRI's position.

Response

It is agreed that the most reactive time in life may not be the beginning of the life cycle. The requirement will be revised to read as follows:

"The spent fuel pool storage racks shall be designed such that subcriticality is maintained for all anticipated fuel management programs, including enrichments for 24 month fuel cycles. Specifically, K_{eff} shall be no greater than 0.95 in non-borated water at optimum moderator conditions with no normally removable poisons in the fuel."

Requirement 2.2.2.2.1 in Chapter 7, Volume II, is worded the same as the requirement in Volume III. The Volume II requirement will also be revised as indicated above.

NRC Question

440.10, Paragraph 2.2.5.2: The NRC criteria are somewhat different than stated in this paragraph. The new fuel storage facility is designed such that k_{eff} is no greater than 0.95 for fully flooded conditions and no greater than 0.98 for low-density (fog or mist) moderator conditions. EPRI should either modify the Requirements Document to reflect this position or provide additional justification for EPRI's position.

Response

Although the requirement in paragraph 2.2.5.2 for K_{eff} was intended to be for all conditions of new fuel storage, the Requirements Document will be changed to be consistent with the stated NRC criteria such that $K_{eff} \geq 0.95$ for fully flooded conditions and $K_{eff} \leq 0.98$ for low-density (fog or mist) moderator conditions. Volume II requirement will also be revised as indicated above.

Reference: NRC letter, E. E. Kintner, dated February 22, 1991

NRC Question

440.11, Paragraph 4.3.4.1: The reactivity of the maximum number of fuel assemblies (six) allowed to be stored in the racks of the fuel transfer system refueling area during fuel shuffle operations must also be shown to meet the k_{eff} no greater than 0.95 criterion. EPRI should either modify the Requirements Document to reflect this position or provide additional justification for EPRI's position.

Response

It is agreed that the fuel transfer area storage racks must also meet the K_{eff} no greater than 0.95 criterion. An additional requirement will be added to address this issue. The new requirement will be equivalent to paragraph 2.2.2.2.1 (K_{eff} no greater than 0.95 for the spent fuel pool):

"The fuel transfer area storage racks shall be designed such that subcriticality is maintained for all anticipated fuel management programs, including enrichments for 24 month fuel cycles. Specifically, K_{eff} shall be no greater than 0.95 in non-borated water at optimum moderator conditions and with no normally removable poisons in the fuel."

Requirements 4.3.4.1 in Chapter 7, Volume II, is worded the same as the requirement in Volume III. The new requirement will also be added to Volume II.