Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37379

September 29, 2000

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - UNITS 1 AND 2 - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION ON THE HOLTEC INTERNATIONAL REPORTS (TAC NOS. MA9101 AND MA9102)

Reference: NRC letter to TVA dated August 2, 2000, "Sequoyah Nuclear Plant, Units 1 and 2 - Request For Additional Information on the Holtec International Reports (TAC Nos. MA9101 and MA9102)"

The purpose of this letter is to provide our response to NRC's request for additional information on the above referenced letter. The proposed approach for responding to each NRC question was discussed in a telephone conference held between TVA, Holtec, and NRC on July 27, 2000. During this conference, a qualitative approach to the response of Question No. 1 was agreed upon due to the continuing review of the equivalent reactivity calculation methodology.

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If you have any questions about this change, please telephone me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

Pedro Salas
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cc (Enclosure):

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ENCLOSURE

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNITS 1 AND 2

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION ON THE HOLTEC INTERNATIONAL REPORTS

NRC Question No. 1

A recent review for the U.S. Nuclear Regulatory Commission of the practice of equating the reactivity of spent fuel to fresh fuel in burnup credit criticality safety analyses for PWR spent fuel pool storage has indicated a possible non-conservatism in certain instances where the calculations are done for configurations that differ from the reference configuration. For example, if the "equivalent" fresh fuel enrichment is used in the reference storage rack configuration (e.g., infinite array of storage rack cells in unborated water) rather than the actual spent fuel isotopics, an under-estimation of k-eff may exist which increases with increasing soluble boron concentration. The results also indicate that equivalencing may yield non-conservative results in configurations in which the spent fuel is placed in storage with higher reactivity assemblies and where soluble boron is credited for a misplaced fresh fuel assembly accident condition. Please provide justification if the "equivalent" fresh assembly concept was used for your spent fuel pool calculations rather than the actual spent fuel isotopics.

Response

We acknowledge that NRC is currently reviewing the methodology used to equate the reactivity of spent fuel to fresh fuel in criticality calculations which take credit for fuel burnup. The preliminary results of this review indicate the potential for nonconservative results when using the methodology in certain applications. NRC may provide additional guidance to the industry on the generic issue when review of the results is complete.

Based on our understanding of the NRC methodology issues as they have been established to date, we qualitatively estimate their effect on the Sequoyah criticality calculations to be small. We have conservatively included a 100 ppm soluble boron concentration margin between the spent fuel pool minimum boron operational limit (800 ppm) and safety analysis limit (700 ppm) to accommodate spent fuel pool criticality calculation uncertainty. We anticipate that resolution of any criticality calculation issues which result from the NRC equivalent reactivity methodology review will be within the margin allotted for generic analysis uncertainty. In the unlikely event that the resolution of the NRC review issues result in calculated criticality changes which exceed the generic uncertainty allotment, the most severe effect will be a small increase in the spent fuel pool minimum boron operability limit with a corresponding small reduction in the spent fuel boron dilution detection and termination time.

The small change is not expected to alter the conclusions of the spent fuel pool boron dilution analysis regarding the ability to detect and terminate a spent fuel pool boron dilution event prior to the loss of the minimum required boron concentration.

Because 1) The results of the reactivity calculation methodology review remain under active study; 2) The concerns raised by the methodology review appear to have only a minor effect on calculated reactivity results; and 3) The Sequoyah spent fuel pool reactivity calculations which credit soluble boron include margin for criticality calculation uncertainty, we consider the equivalent fresh fuel methodology used for the Sequoyah spent fuel pool criticality calculations to be adequate to support the proposed license amendment changes. Any further justification of the adequacy of the methodology will be provided in response to any generic NRC requirements issued upon completion of the methodology review.

NRC Question No. 2

You state that the use of an axial burnup distribution profile, as opposed to an assembly-average uniform burnup over the burnup range of interest, results in a slightly lower k-eff which is conservatively neglected in your k-eff analysis. This is attributed to the lower reactivity worth of the more reactive fuel in the end regions due to the neutron leakage. However, for the cooling time analyses, since the ends of the assembly are more reactive (less burned) than the center, was the actinide decay credit based on the fuel burnup at the assembly ends rather than an assembly average burnup? If not, please justify.

Response

The evaluation of the reactivity penalty due to the axial burnup distribution includes the actinide elements and their distribution in the analyses. In evaluating the effect of cooling time, the actinide decay credit was not based solely on the fuel burnup in the ends (as indicated in the RAI), but rather on the actinide decay in each of the 10 axial segments used in the analysis. The change in the axial burnup penalty with cooling time is due nearly entirely to the decay of Pu-241 and growth of Am-241. Since there is a lower burnup in the ends of a spent fuel assembly than in the center, the reactivity decrease with cooling time will be less at the ends than in the center. This results in an increase in the end effect penalty with cooling time for individual spent assemblies. However, in checkerboard arrays with fresh fuel assemblies, the higher reactivity of the fresh fuel dominates the reactivity. Since the flux distribution resulting from

the higher reactivity fresh assembly is strongly peaked at the center (nearly cosine shaped as explained in the licensing submittal), the lower reactivity center of the spent fuel assemblies in the checkerboard array is flux weighted more heavily at the ends. The net effect of the fresh fuel assembly in the checkerboard array suppresses or greatly reduces the end effect that might otherwise exist. These effects are included in the analyses submitted.

NRC Question No. 3

Which nuclides were included in the cooling time analyses? What uncertainties were assumed?

Response

The nuclides included in the cooling time analysis were those normally included and tracked in the CASMO4 computer code. Over the time period involved in the cooling time analyses, there is only minor and almost negligible change in the nuclide concentrations, except for Pu-241 and Am-241. Pu-241 and Am-241 growth account for the majority of the post-shutdown reactivity changes. Since the Pu-241 decay constant is well characterized and reactivity effects well validated by Studsvik in numerous benchmark evaluations over many years, no additional uncertainties were included beyond the very conservative allowance already included in the analyses.

NRC Question No. 4

Since part of the uncertainty in burnup calculations derives from uncertainties in the fuel and moderator temperatures and the spectral effect of soluble boron during core operation, how are these uncertainties included?

Response

There are two parts to this RAI which may be addressed separately:

A. Moderator and Fuel Temperature Uncertainties

The criticality safety analyses were made with values of fuel and moderator temperatures conservatively higher than the average temperatures in the core during reactor operation. The fuel temperature is a function of burnup and at SQN ranges from 1250 °F at 1000 MWD/MTU to 1000 °F at 40,000 MWD/MTU, the latter being perhaps the more important. A fuel temperature of 1370 °F was used in the

analysis. This temperature is conservative and allows for some power peaking. Thus, no additional uncertainty is considered necessary.

The coolant in the SQN core enters at approximately 545 °F and exits at approximately 616 °F, with an average of 582 °F at full power. The criticality analyses used a temperature of 592 °F, which is a conservative 10 °F above the average. The small volume of the core near the top where the local temperature would be higher than the average used is too small to appreciably increase the spent fuel reactivity and would be compensated by the much larger volume of lower reactivity moderator. Furthermore, the spent fuel axial burnup distribution inherently accounts for higher reactivity at the upper end of the assembly. Consequently, no additional uncertainty is considered necessary.

B. Soluble Boron

The criticality analyses assumed an average soluble boron concentration of 425 ppm. Since the soluble boron letdown curve varies each cycle, additional calculations have been made based on the maximum average soluble boron let down concentrations observed at SQN to ensure adequate uncertainties have been applied. These calculations were made for an averaged boron concentration of 700 ppm and for the actual letdown curve, assuming the average boron concentration over each 1000 MWD/MTU burnup. The results of these two calculations were the same and both were 0.0027 Δk higher at 30 MWD/kgU and 0.0035 Δk at 40 MWD/kgU than that for the original calculation at 425 ppm soluble boron. These uncertainties are well within the conservative allowance of 5percent of the reactivity decrement already included in the analyses as an uncertainty for just such circumstances. Furthermore, in a checkerboard array with fresh fuel, the higher reactivity of the fresh fuel assembly would reduce the small reactivity uncertainty impact associated with the core soluble boron concentration of the irradiated fuel. Because of this allowance and other conservatisms included, no additional uncertainty is considered necessary.

NRC Question No. 5

Statement (1) on page 15 appears contradictory. Should the word "too" be inserted before "low"?

Response

Yes. The word "too" was inadvertently omitted and should be inserted.

NRC Question No.6

Please explain the reason for assuming the removal of a burnable poison rod assembly (BPRA) at 30,000 MWD/MtU and deriving a reactivity penalty due to this removal. Does this penalty include the non-conservative effect of depleting the remainder of the assembly life over a softer spectrum?

Response

In the evaluation of the effect of BPRAs, the reactivity penalty results from operating with BPRAs for 30,000 MWD/MTU. The BPRAs were removed at 30,000 MWD/MTU and the remainder of the depletion calculation continued in the "softer" neutron spectrum. We do not consider this as a "non-conservatism" but rather as a very conservative calculation of the actual depletion. BPRAs, after their virtual depletion of boron in one cycle of operation (approximately 15,000 to 20,000 MWD/MTU) are normally removed from the fuel. To continue them in the next cycle would be a reactivity penalty that would adversely affect core design. To continue their presence for a third cycle would seriously affect the efficiency of the operating cycle. The calculations, as presented, are conservative for the following reasons:

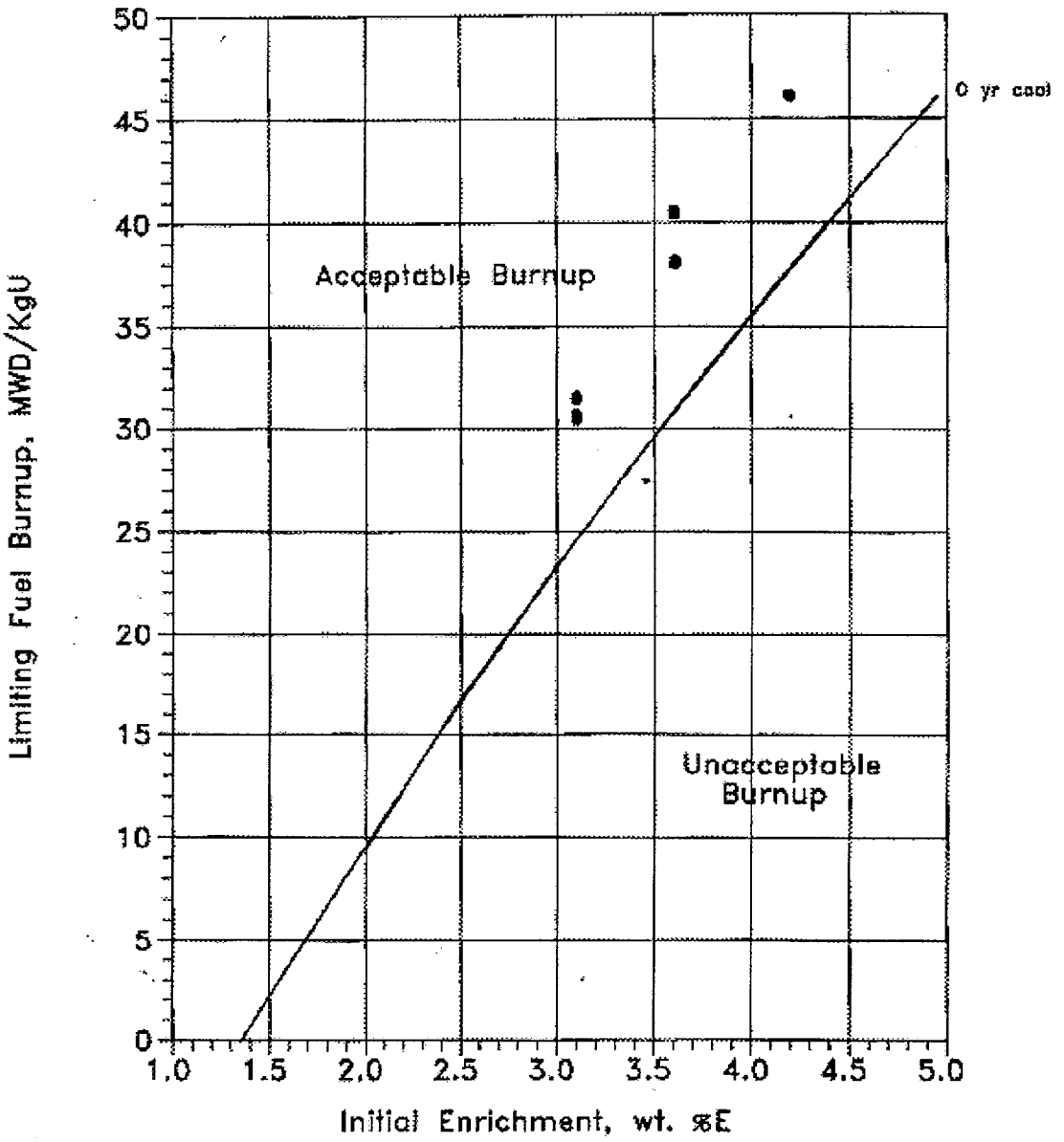
The analyses assume the BPRAs remain in the fuel for 30,000 MWD/MTU which is greater than typical operation.

The analyses assumed all assemblies contained BPRAs with 24 rods each, whereas the actual number of rods in a BPRA assembly ranges from 4 to 24 and averages about half of the maximum number.

The boron loading in the BPRAs used in the analyses was the maximum currently designed in contrast to the lower loadings actually used in the core.

A flow induced vibration problem in a former fuel design used at SQN led to the reinsertion of spent BPRAs into fuel assemblies which had already operated with a BPRA. As an interim measure to allow continued use of these fuel

assemblies spent BPRAs were reinserted, not for reactivity control, but as mechanical stiffeners to limit the flow vibration. During the additional cycles, these fuel assemblies never contained more than 12 BPRA rods and were restricted to peripheral cell locations where the reactivity penalty of the stiffener rods would not be as great and could be tolerated. Most of these assemblies did not accumulate 30,000 MWD/MTU of burnup during their time incore with a BPRA. A correlation has been made for the 36 fuel assemblies which operated for more than 30,000 MWD/MTU of burnup with BPRAs present. The attached Figure shows the minimum required burnup (0 cooling time) with the enrichment and actual burnup values superimposed. These 36 fuel assemblies have burnups at least 6,000 MWD/MTU above the minimum required, which is more than adequate to safely compensate for any reactivity effects of the stiffener rods beyond the 30,000 MWD/MTU of burnup already accounted for in these analyses. A new fuel assembly design has eliminated the flow induced vibration concern in subsequent generations of fuel assemblies and BPRAs are no longer used more than one cycle. In addition, core designs at SQN currently use BPRAs sparingly, opting to use integral burnable poisons instead.



Graph of Actual Burnups of Fuel Assemblies with BPRAs Present for More Than 30 Mwd/KgU Compared to Minimum Required Burnup