FOSTER WHEELER ENVIRONMENTAL CORPORATION

March 18, 2004
FW-NRC-ISF-04-0059

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington DC, 20555-0001

**SUBJECT: FOSTER WHEELER ENVIRONMENTAL CORPORATION
IDAHO SPENT FUEL (ISF) FACILITY
RESPONSE TO NRC FOLLOW-UP CRITICALITY QUESTIONS
DOCKET 72-25
TAC NO. L23389**

Dear Sir or Madam:

Based on additional communication with the NRC Staff on March 9, 2004, enclosed please find the Foster Wheeler Environmental Corporation (FWENC) responses to the NRC follow-up questions relating to the criticality analyses presented in the ISF Safety Analysis Report.

This letter is being submitted by Ronald D. Izatt on behalf of Foster Wheeler Environmental Corporation, and under the delegation of authority from Bernard H. Cherry, FWENC Chairman, President & CEO. This delegation of authority was provided to the NRC by FWENC letter FW-NRC-ISF-04-0046 dated February 25, 2004.

Should you have any questions with this matter, please contact James Saldarini, ISF Facility Licensing Manager, at (509) 372-5870.

Sincerely,

Ronald D. Izatt
ISF Facility Project Manager
Tetra Tech FW, Inc.

RDI/jcs

Enclosure: FWENC Response to NRC Follow-up Criticality Questions

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Enclosure to FW-NRC-ISF-04-0059

FWENC Response to NRC Follow-up Criticality Questions
Docket 72-25
TAC No. L23389

Question 1 – Worktable Operations

Clarify the statement in SAR Section 4.7.3.4.4, Fuel Packaging Area Operations, "Worktable operations may involve movement of fuel fragments, single[intact] *fuel elements or multiple* [intact] *fuel elements" to indicate whether more than one fuel element may be moved outside of a fuel basket or canister on the worktable at a time. If more than one fuel element may be handled outside of a fuel basket, revise the application as necessary to ensure that the criticality evaluation encompasses these conditions, (i.e., that the criticality calculations of loose fuel rods in Appendix A evaluate more rods than will be handled outside of a basket on the worktable).*

FWENC Response:

Worktable operations may involve the handling of more than a single intact fuel element outside of a fuel basket. The results of criticality analyses presented in SAR Appendix 4A support worktable operations involving more than a single fuel element. As summarized in SAR Table 4.7-32, up to 21 Peach Bottom elements can be completely crushed into a spherical geometry without approaching a critical configuration (See SAR Appendix 4A Section 3.2). For TRIGA fuel, the analyses in Appendix 4A demonstrate that up to 45 fuel elements can be closely packed with concrete walls providing moderation on three sides without reaching a critical configuration (See SAR Appendix 4A Section 2.5). These criticality analyses bound any potential scenarios involving worktable operations.

Question 2 – Rhodium Credit

Clarify whether Rhodium is a neutron poison in the Peach Bottom fuel. Based on the number density tables in Appendix A, rhodium appears to be included in the criticality evaluation for Peach Bottom fuel. FWENC response to NRC question 8-1, dated August 28, 2003, stated "FWENC intended to model all fuel as fresh, (i.e., no burnup), containing the as designed quantity of fissile material, and without neutron poison material present in the fuel element or the fuel storage baskets/canisters." Rhodium is one of the primary fission products that will be used in burnup credit, which lends credence to questioning whether it was used as a burnable poison in the Peach Bottom fuel elements.

FWEENC Response:

Rhodium included in the criticality models and reflected in the material density tables in SAR Appendix 4A is only that material that is present as a homogenous component of the Peach Bottom fuel compacts. This small concentration of rhodium is not a result of credit taken for burnup or the inclusion of burnable poison components in the criticality models.

Criticality analyses for the ISF project used fresh fuel (i.e., no burnup) containing the design quantity of fissile material and neglected the neutron poison material present in the fuel element or the fuel storage baskets and/or canisters. In adopting this approach FWENC disregarded all the discrete burnable poisons that were either added to the Peach Bottom fuel element or the ISF basket. For instance, natural boron in the form of zirconium diboride pressed into a cylindrical graphite matrix was used as a natural burnable poison compact placed in the hollow spines of some of the fuel elements. This material was omitted from the Peach Bottom criticality models. Likewise, the gadolinium phosphate that will eventually be added to the basket in compliance with geologic repository requirements was omitted from the Peach Bottom criticality analyses.

In contrast to the discrete burnable poisons, rhodium (as modeled) is a homogenous component of the Peach Bottom fuel compact. Rhodium was used to aid this fuel in achieving a prompt negative temperature coefficient of reactivity[1]. Its presence at less than 1% of the fuel element initial heavy metal loading has a negligible effect of the calculation of k_{eff} for criticality analyses involving Peach Bottom fuel.

Absent specific testing, regulatory guidance requires the omission of discrete neutron poisons for criticality analysis and credit for the effects of fuel burnup is restricted. FWENC feels that this guidance has been met with the analyses included for Peach Bottom fuel. Discrete burnable poisons (i.e., boron, gadolinium phosphate) were omitted and fission products resulting from fuel burnup were not included or evaluated in the criticality models. Rhodium was included only in the documented fresh fuel concentration as a homogenous component of the fuel matrix.

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[1] Characterization of Peach Bottom Unit 1 Fuel, R.P. Morisette, N. Tomsio, J. Razvi, ORNL/Sub/86-22047/2, GA-C18525, October 1986 (SAR Section 4A, Section 3.1.6, "References")

Question 3 – Vault Neutronic Isolation

FWENC response to NRC question 8-2, dated August 23, 2003, states there is neutronic isolation between fuel baskets in the vault, but criticality calculations do not appear to substantiate this statement. FWENC response to NRC Question 8-2, dated August 28, 2003, provides revised TRIGA criticality calculations for a higher fuel loading, which show the k_{eff} of Vault 2 loaded with TRIGA rods to be 0.8153, while Table 41 in Appendix 4A shows the k_{eff} of one Peach Bottom fuel element and two stacked TRIGA baskets to be 0.838. The k_{eff} of 0.023 does not appear to show neutronic isolation of the two baskets. Since the TRIGA baskets appear to be the limiting case, it is not clear why the k_{eff} for the mixed fuel type is larger than for Vault 2 full of TRIGA baskets. Either show neutronic isolation, or revise the criticality calculation as necessary to include a larger array size for the mixed fuel calculation.

FWENC Response:

SAR Appendix 4A, Section 3.5 provides a criticality analysis for a storage tube containing a TRIGA canister adjacent to a storage tube containing a Peach Bottom canister. This analysis was originally performed during the preliminary design phase for the ISF facility. As such, assumptions made in the development of the MCNP model were conservative so as to ensure that the reported k_{eff} would be very conservative for adjacent tubes of mixed fuel types. Subsequent analyses described in response to Round 1 RAI 8-14 were performed that justified the assertion that the TRIGA vault calculation is the bounding case for storage conditions in the ISF Facility. The higher value of k_{eff} in Section 3.5 vs. the analysis for a fully loaded vault of TRIGA canisters provided in Section 2.3 arises from differences between the these two models.

The full vault of TRIGA fuel is the bounding case for the ISF Facility storage configuration. This analysis was added in Amendment 2 to the SAR consistent with FWENC's response to Round 1 RAI 8-14 and replaced previous conservative bounding calculations for an infinite array of TRIGA storage tubes. This model is more representative of the actual storage vault and storage tube final design.

To further confirm that this case is bounding and that the vault storage tubes are neutronically isolated, FWENC has performed an additional series of calculations for each of the fuel types as well as mixed fuel vault configurations. A storage tube containing one canister of TRIGA fuel was modeled adjacent to another storage tube of identical configuration. Each tube was fully flooded (moderated) and reflected, similar to the case of the full TRIGA vault. The calculated $k_{eff} + 2\sigma$ of this configuration of storage tubes was 0.8165. Figure 1 illustrates the geometry, minus the moderator and reflector (for clarity), that was evaluated. A 3x3, then a 5x5 array of TRIGA storage tubes was modeled and k_{eff} calculated for these fuel systems to determine if a significant variation from the adjacent storage tubes was noted. The calculated values of $k_{eff} + 2\sigma$ were 0.8156 and 0.8165, respectively. Figures 2 and 3 illustrate the geometrical configuration of these two models. The similarity in k_{eff} for the various array sizes substantiates the FWENC position that the storage tubes are neutronically isolated from each other.

To further highlight this fact and show TRIGA to be the bounding fuel type, two scenarios involving Peach Bottom fuel were also modeled and evaluated. The first was adjacent storage tubes of Peach Bottom fuel, as illustrated in Figure 4, and the second was a 3x3 array of Peach Bottom storage tubes shown in Figure 5. The computed $k_{eff} + 2\sigma$ values of 0.4276 and 0.4255 respectively, were much lower than the TRIGA storage tube arrays. Again, essentially no difference is observed between the two k_{eff} values showing that the tubes are isolated neutronically from one another. This is true independent of the type of fuel inserted into the storage tubes when the analysis is conducted.

Finally, adjacent storage tubes of mixed fuel (shown in Figure 6) and a 3x3 array of mixed fuel storage tubes (shown in Figure 7) were modeled and evaluated. The adjacent storage tube configuration produced a calculated $k_{eff} + 2\sigma$ of 0.8143 and the 3x3 array had a calculated $k_{eff} + 2\sigma$ of 0.8158.

The results of these cases are summarized in the table below.

Storage Tube Configuration	$k_{eff} + 2\sigma$
3 x 3 TRIGA	0.8156
5 x 5 TRIGA	0.8165
1 x 2 Peach Bottom	0.4276
3 x 3 Peach Bottom	0.4255
1 x 2 Mixed	0.8143
3 x 3 Mixed	0.8158

In cases where TRIGA fuel was present, the calculated $k_{eff} + 2\sigma$ ranged from 0.8143 to 0.8165. The variations in these results are within the statistical uncertainty of the analyses. When similar models with only Peach Bottom fuel present were analyzed, the calculated $k_{eff} + 2\sigma$ ranged from 0.4255 to 0.4276. Based on these results, FWENC concludes that TRIGA fuel is the primary driver for k_{eff} calculations and, thus, the bounding fuel type.

TRIGA Cases Evaluated for Neutronic Isolation

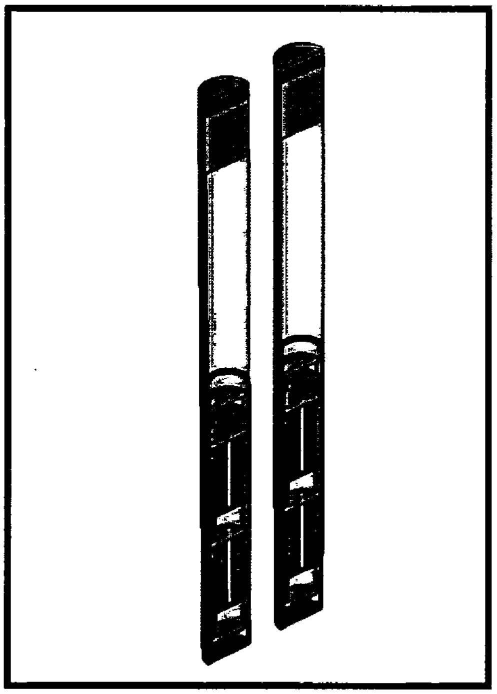


Figure 1 - Adjacent TRIGA Storage Tubes

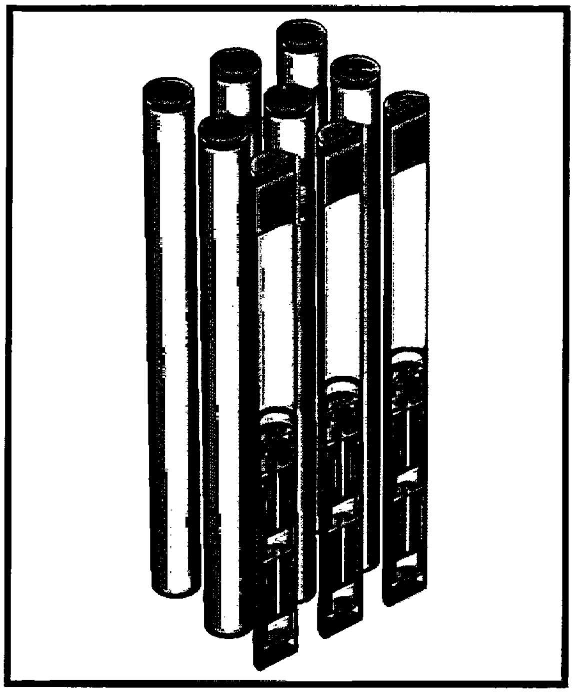


Figure 2 - 3x3 Array of TRIGA Fuel

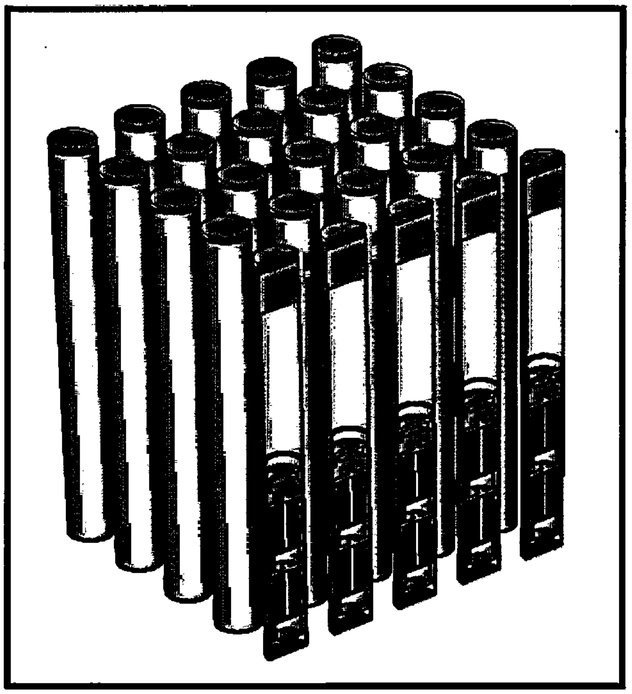


Figure 3 - 5x5 Array of TRIGA Fuel

Peach Bottom Cases Evaluated for Neutronic Isolation

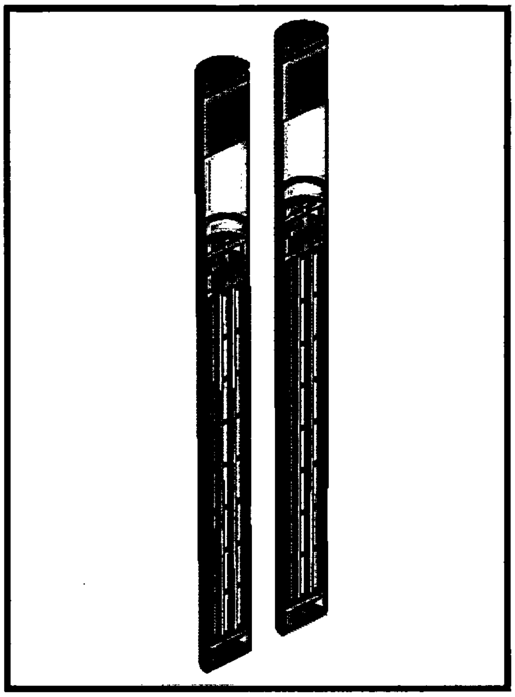


Figure 4 - Adjacent Storage Tubes of Peach Bottom Fuel

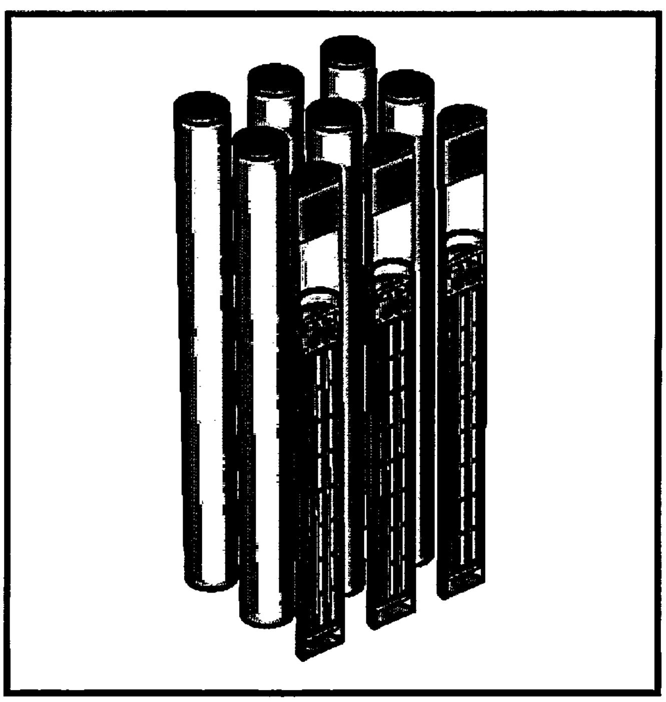


Figure 5 - 3x3 Array of Peach Bottom Fuel

Mixed Fuel Cases Evaluated for Neutronic Isolation

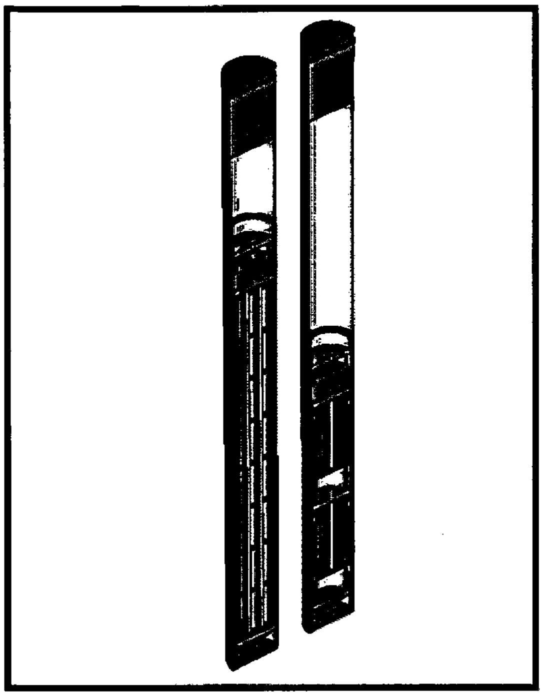


Figure 6 - TRIGA Storage Tube Adjacent to Peach Bottom Storage Tube

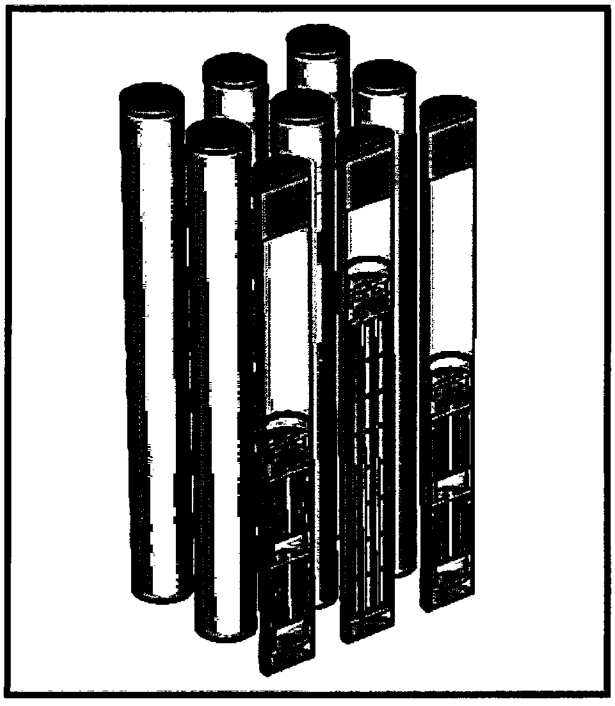


Figure 7 - 3x3 Array of Mixed Fuel Storage Tubes

Question 4 – MCNP 4C Bias Evaluation

The revised benchmarking analysis for MCNP 4C should have been evaluated for trends in the data, similar to the method for the MCNP Version 4B2 benchmarking. Statistically averaging all k_{eff}s to determine the bias is only appropriate when no trends exist in the data. Show that there are no trends in k_{eff} for the critical experiments, when compared against typical criticality safety variables, such as those shown in Table 4.2 of NUREG/CR-6361, "Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages" for both Peach Bottom and TRIGA fuel for MCNP Version 4C.

FWENC Response:

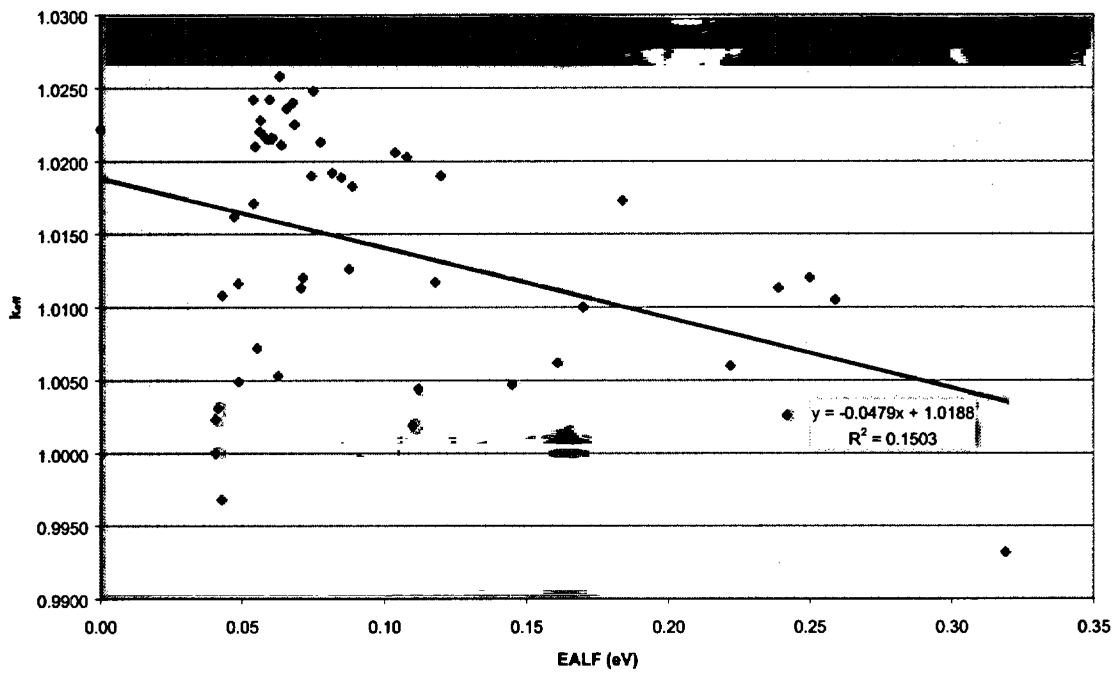
Trending data currently included in the SAR relative to MCNP4B2 benchmarking was incorporated in Amendment 3 to the SAR as a result of FWENC's response to Round 2 RAI 8-4. In response to the request to evaluate trends, the k_{eff} values obtained from the critical benchmark experiments used in the MCNP4B2 validation were plotted as a function of U-235 enrichment and the average neutron lethargy causing fission. These plots (SAR Appendix 4A Figures 59 and 60), demonstrate there are no clear trends discernable from the data.

The criticality benchmark experiments used for the bias evaluation of MCNP4C show similar results, i.e. there are no clear data trends discernable from the data. The following graphs plot the results of the benchmark cases as a function of several parameters for both Peach Bottom and TRIGA fuels. These parameters include:

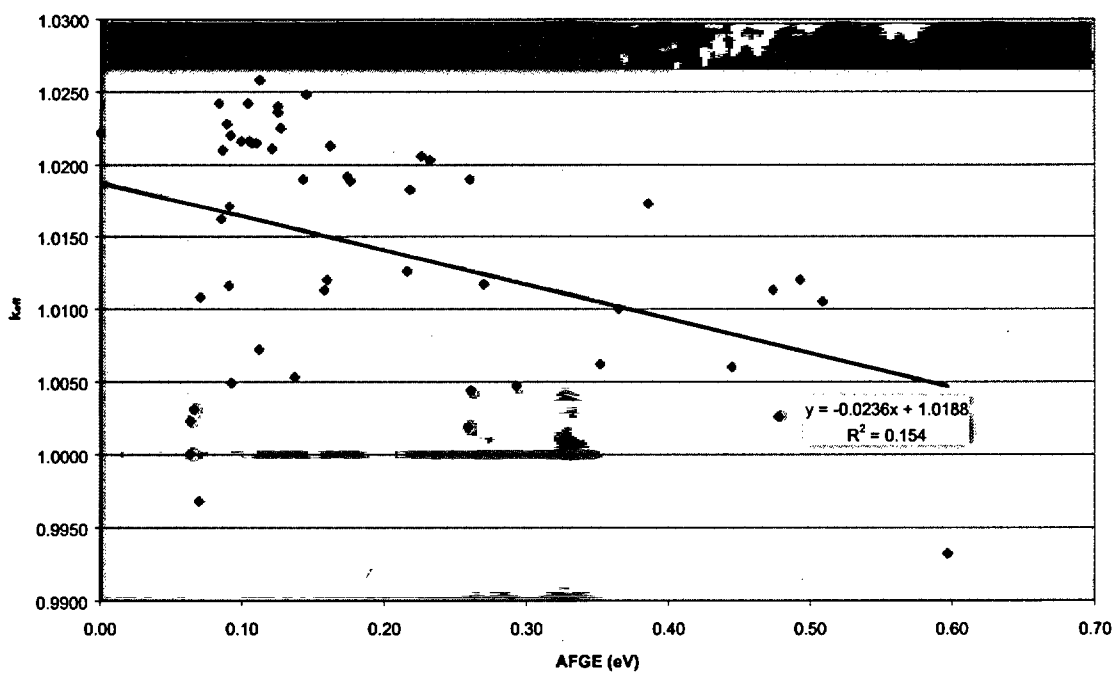
- Energy of Average Neutron Lethargy Causing Fission (EALF)
- Average Fission Group Energy (AFGE)
- moderator/fuel volume ratio
- U-235 weight percent

Peach Bottom Bias Cases

k_{eff} vs. Energy of Average Neutron Lethargy Causing Fission (EALF)

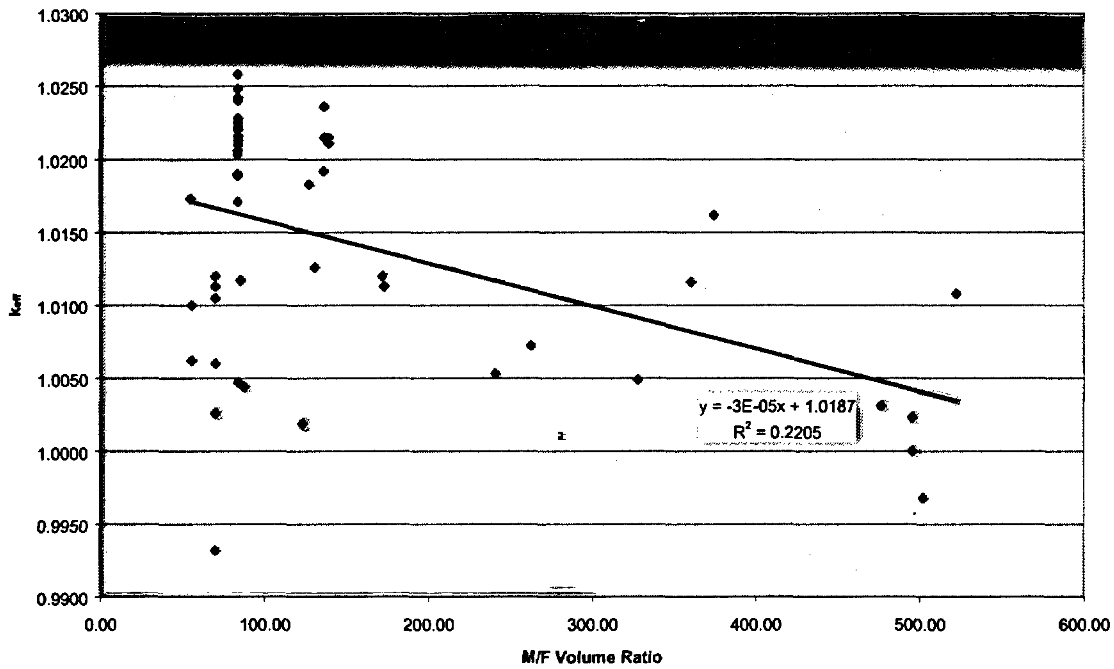


k_{eff} vs. Average Fission Group Energy (AFGE)

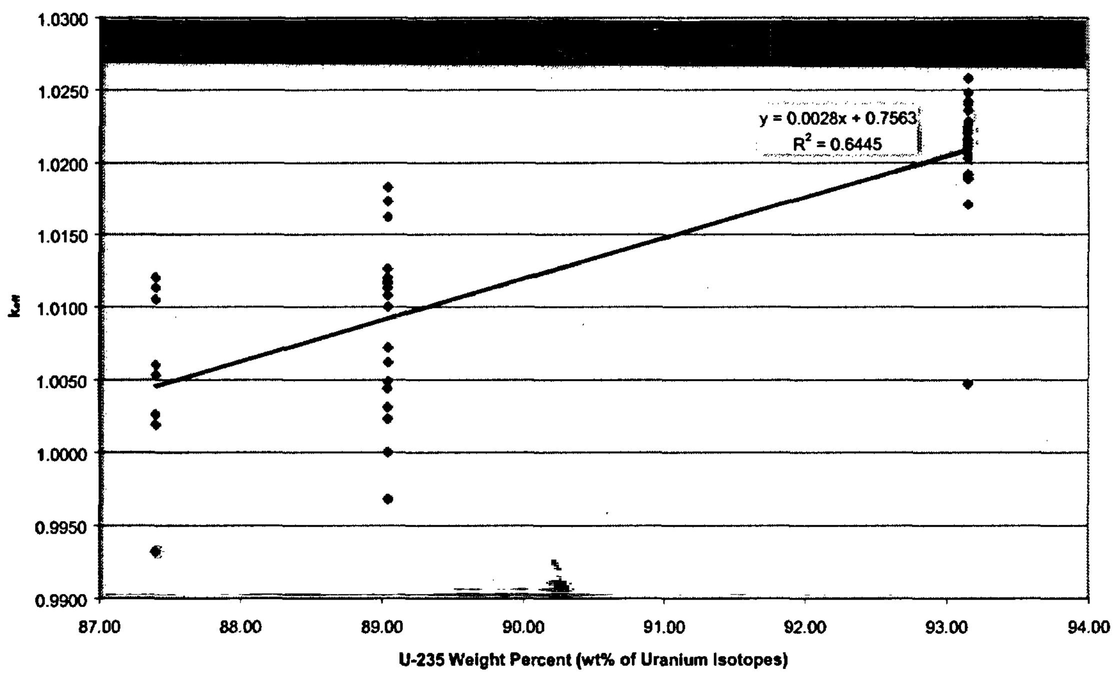


Peach Bottom Bias Cases (cont.)

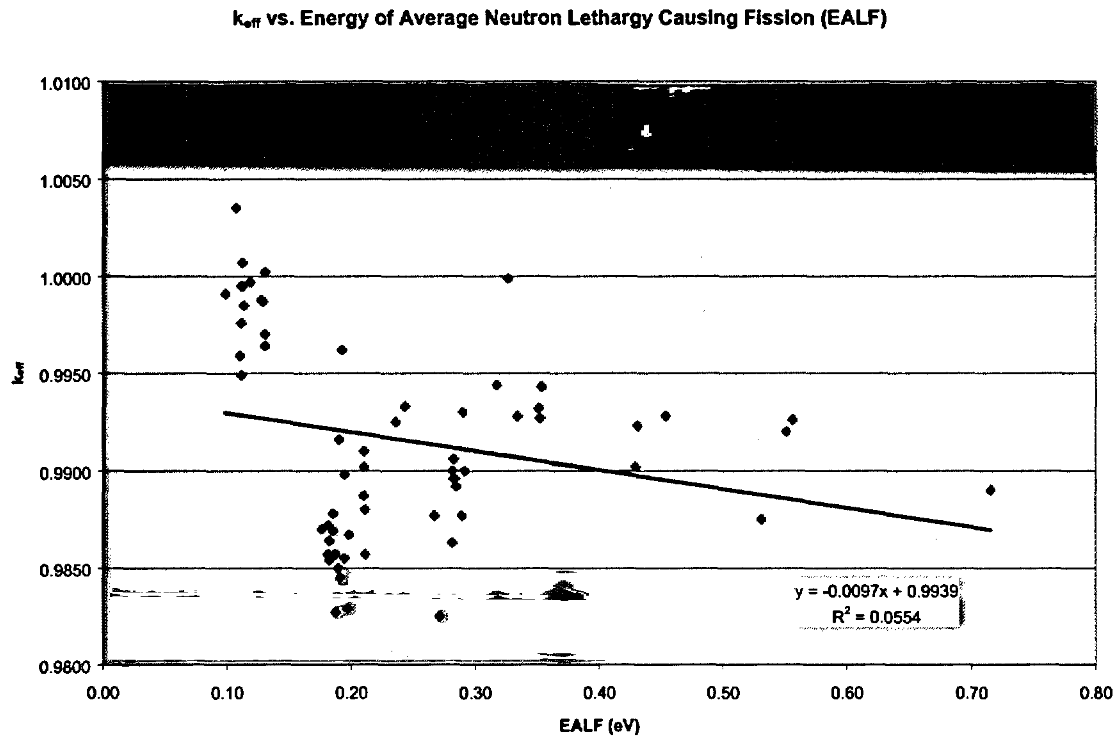
k_{eff} vs. Moderator / Fuel Volume Ratio

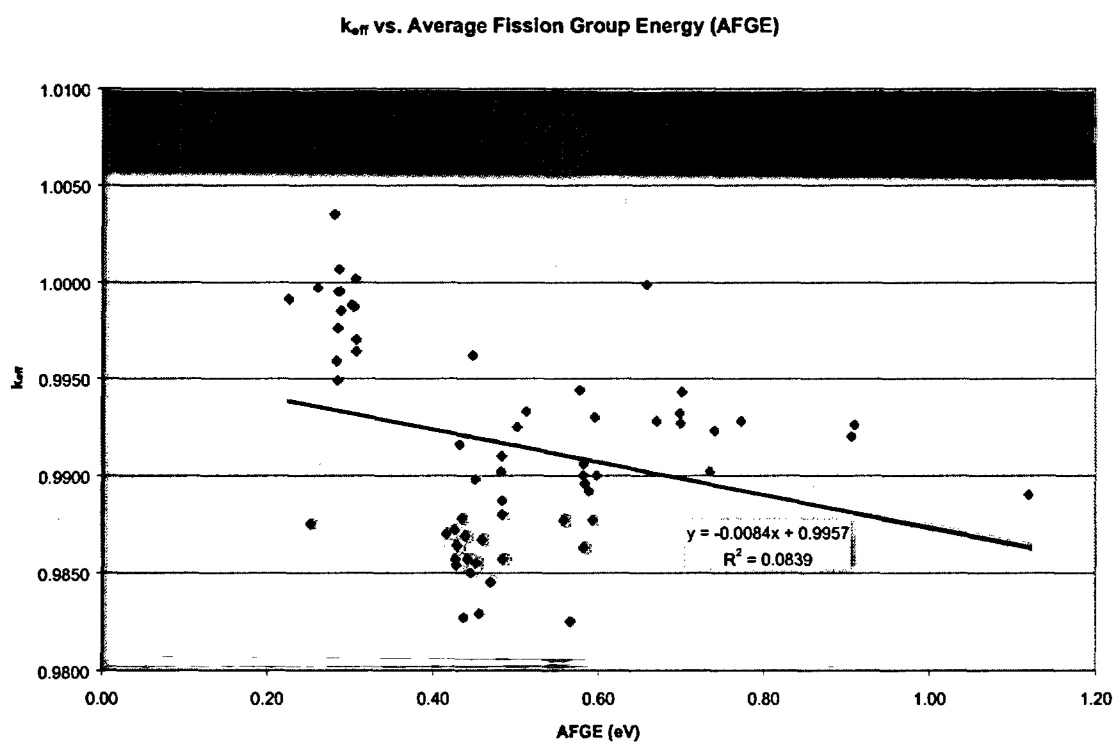


k_{eff} vs. U-235 Weight Percent



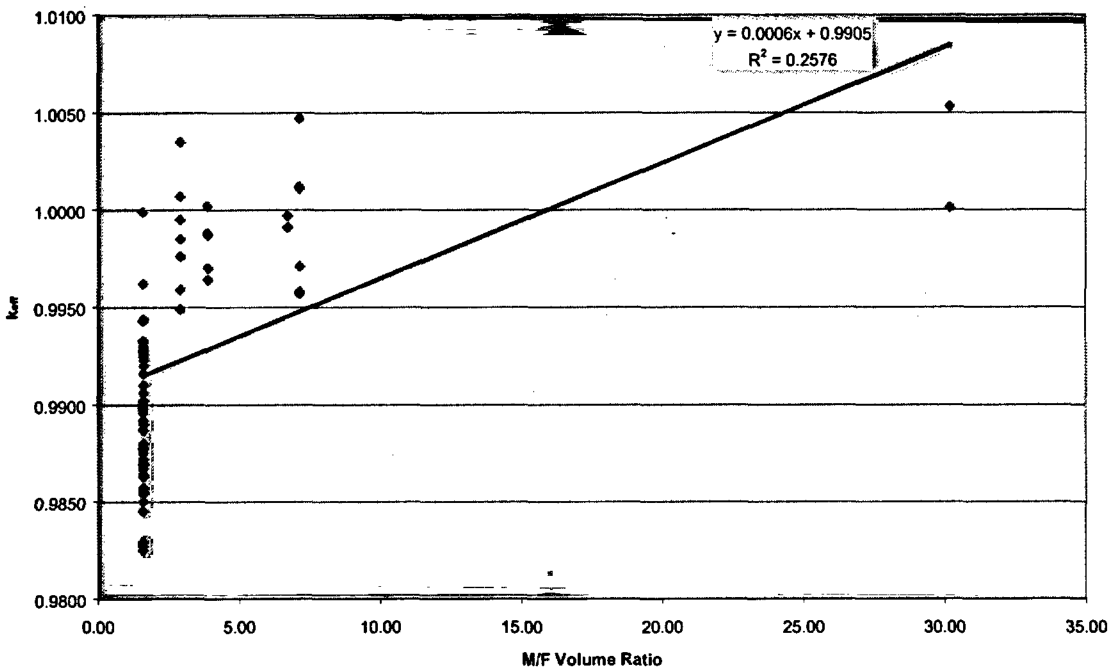
TRIGA Bias Cases



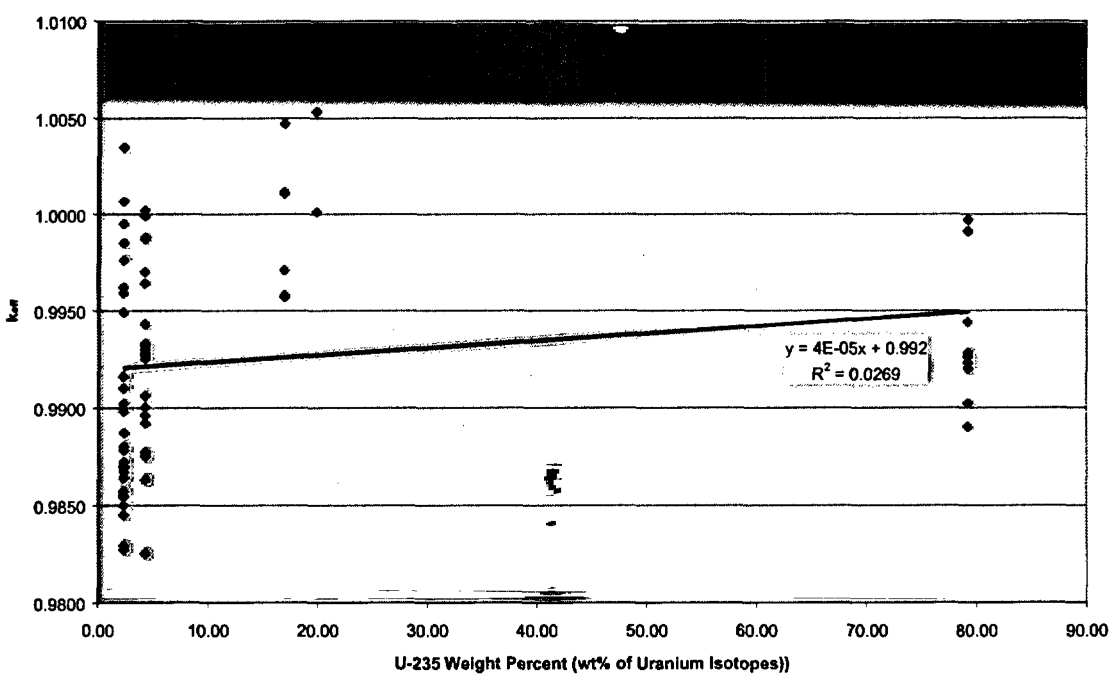


TRIGA Bias Cases (cont.)

k_{eff} vs. Moderator / Fuel Volume Ratio



k_{eff} vs. U-235 Weight Percent



Question 5 – Normalized vs. Statistical Average k_{eff}

Clarify whether the normalized k_{eff} used in section 5.2.3 of Appendix 4A utilizes the minimum calculated k_{eff} or a statistical average.

FWENC Response:

As described in SAR Appendix 4A Section 5.2.2, "Validation Approach," the value of k_{eff} used to derive K_L (the combination of bias and bias uncertainty) is the lowest observed k_{eff} from the dataset. In this case, the lowest observed value of k_{eff} (normalized) is shown in Table 46 as 0.9842 for Case HMT0306.

The calculation of the USL shown in Section 5.2.3 conservatively rounded this value down to 0.9840, with the corresponding USL calculated to be 0.9130.

Editorial – Number of Critical Experiments Evaluated

Page 4A-139 should say there are 56 critical experiments to be consistent with Table 45 of the same appendix. Clarify that the benchmarking analysis was performed for the proper number of critical experiments.

FWENC Response:

As noted in Table 45, "Benchmark Experiment Descriptions for Validating MCNP4B2 Code," FWENC considered a total of 56 experiments for the validation of the MCNP4B2 code. These experiments and their results are detailed in Table 46, "Calculation Results for 56 Critical Experiments." As noted in the footnote in Table 46, however, one experiment (HMT0613) was determined to be anomalous and was not used in the bias calculation described in Section 5.2. Therefore, as noted in Section 5.2.1, the number of critical experiments used in determining the bias for the MCNP4B2 computer code system is 55.