RAS 8247

Exhibit 1

Relevant Portions of Duke Energy's License Amendment Request Submitted to the NRC, February 27, 2003

(Attachment 3, Section 3.7.1)

Template=SECY-028

SECY-02

enhanced security requirements during receipt, handling, and storage of unirradiated MOX fuel assemblies. The specific changes to this plan will be submitted separately with the intent of having additional security measures and associated plan changes approved in the same time frame as the license amendments.

3.7 SAFETY ANALYSIS OF MOX FUEL LEAD ASSEMBLIES

The MOX fuel lead assemblies have slightly different nuclear and thermal-hydraulic characteristics from the resident Westinghouse LEU fuel assemblies. The effect of these differences on the design basis transients and accidents described in the UFSAR were evaluated to verify that acceptance criteria continued to be met for the MOX fuel lead assemblies.

3.7.1 Impact of MOX Fuel Lead Assemblies on Loss of Coolant Accident Analyses

The effects of MOX fuel lead assemblies on core operating and safety limits with respect to loss of coolant analyses (LOCA) were evaluated. With the conservative calculation approach described herein, there were no significant differences in the predicted performance of MOX fuel relative to LEU fuel for LOCA. This conclusion is based on an evaluation of MOX fuel with respect to isotopic content, decay heat, fuel material properties, and on representative LOCA calculations.

MOX fuel phenomena that have the potential to affect LOCA results are addressed in Section 3.7.1.1. Some adjustments to the Framatome ANP large break LOCA evaluation model are required to model MOX fuel. These adjustments are discussed Section 3.7.1.2. A limited set of large break LOCA calculations comparing MOX fuel lead assemblies to LEU fuel assemblies are summarized in Section 3.7.1.3. Section 3.7.1.4 contains a description of the set of MOX fuel lead assembly large break LOCA calculations that will be performed prior to operation with the lead assemblies. Section 3.7.1.5 addresses potential MOX fuel impacts on small break LOCA evaluations. Section 3.7.1.6 discusses potential mixed core loading effects for the MOX fuel lead assemblies.

3.7.1.1 MOX Fuel Phenomena and Lead Assembly Design Features that Potentially Affect LOCA

This section addresses the effects of the MOX fuel isotopics on LOCA performance. It is concluded that the changes in delayed neutron fraction and void reactivity feedback are not significant for the lead assemblies and the use of the LEU decay heat standard is shown to be conservative for application to MOX fuel.

3.7.1.1.1 Fissionable Isotope

The key difference between MOX fuel and LEU fuel is that Pu-239 is the predominant fissionable isotope in the MOX fuel. The substitution of a MOX fuel assembly for a LEU fuel assembly affects the assembly neutronic behavior, its neutronic interaction with the rest of the core, and the fission product concentrations. Neutronic interaction between MOX and LEU fuel assemblies occurs through the energy spectrum of the neutron flux. It is primarily embodied in a change of the delayed neutron fraction (β_{eff}), the void reactivity effect, and the prompt neutron lifetime. The Doppler reactivity effect between MOX and LEU fuel is similar and not of consequence in predicting the peak cladding temperature during a LOCA. The differing concentrations of fission products and nuclei activation alter the decay heat rate between MOX and LEU fuel pins. However, as discussed in Section 3.7.1.1.2, LEU fuel decay heat modeling required by current NRC regulations remains conservative for application to MOX fuel.

Delayed Neutron Fraction (β_{eff})

The fraction of delayed neutrons (β_{eff}) is lower in MOX fuel than in LEU fuel. As an example, the delayed neutron fraction for a 40 percent MOX fuel batch application will be reduced from around 0.0063 to about 0.0050 at beginning-of-life (BOL) conditions. This difference has two effects: (1) reactivity changes imposed on the core will produce a larger change in fission power, and (2) the neutron source for shutdown fission power will decrease. Both effects act to lower the power of the MOX fuel assembly relative to the LEU assembly during the transient.

Change in Void Reactivity Feedback

During LOCA, the void effect is responsible for achieving reactor shutdown and maintaining low fission powers in the unquenched regions of the core. Figure 3-2 provides a comparison of a void reactivity curve (effect on assembly k_∞) for a reference Framatome ANP designed LEU fuel assembly with a void reactivity curve calculated for a weapons grade MOX fuel assembly at the same conditions. A larger negative reactivity insertion occurs for the MOX fuel assembly than for the LEU assembly for all void fractions. This effectively suppresses the MOX fuel assembly power relative to the LEU assembly throughout a LOCA.

Prompt Neutron Lifetime

The prompt neutron lifetime decreases for MOX fuel cores. For a 40 percent MOX fuel batch application the lifetime can decrease by approximately 25 percent. This change will not affect LOCA calculations because the prompt neutron lifetime only becomes important for positive reactivity insertions greater than β_{eff}.

Use of Pre-LOCA Peaking throughout LOCA Simulation

The LEU fuel LOCA evaluation model assumes constant local peaking factors throughout the accident simulation. If k_∞ of any assembly does not monotonically decrease with increasing voiding, then local assembly peaking (assembly power relative to core average power) can increase during portions of the accident. This could increase the hot pin peaking factor for the fission component of the pin power and bring the assumption of constant peaking into question. However, an examination of the void reactivity function for the plutonium concentrations anticipated for the lead assemblies, Figure 3-2, shows that the local k_∞ for both the MOX fuel and the LEU fuel assemblies is monotonically decreasing with increasing void fraction. Thus, the hot assembly (highest void fraction) power levels are continuously suppressed during the evolution of the accident and the application of the initial peaking factors is justified and conservative for MOX fuel as well as for LEU fuel.

Combined Effects on LOCA

Each of the neutronic effects identified as significantly differing between MOX fuel and LEU fuel results in a potential benefit in the MOX fuel parameter value over the corresponding LEU fuel value. Taken together these changes assure that the heat load within the MOX fuel lead assembly during LOCA will be lower than that in the resident LEU assembly. Thus, with all other processes being equal, core cooling mechanisms will more effectively control the cladding temperatures in the MOX fuel assembly than in the LEU fuel assemblies. The actual changes for the lead assemblies will not be significant because the effect of four assemblies on the core neutronic behavior will be limited and the MOX fuel assemblies will be substantially driven by the surrounding LEU fuel assemblies. Because the trend of the neutronic parameters is to the benefit of the MOX fuel assembly, it is conservative, as is done herein, to use LEU fuel neutronic parameter values in MOX fuel LOCA calculations.

3.7.1.1.2 Decay Heat

The fission product decay heat rate for MOX fuel assemblies, representative of the lead assembly design, was determined using the 1994 ANSI/ANS 5.1, "Decay Heat in Light Water Reactors." The actinide heat rate was determined using ORIGEN-S with the SAS2H procedures in the SCALE code system (Reference 9). The result, including the appropriate uncertainties, is that the sum of the decay heat and actinide heat for the lead assemblies, for fully saturated decay chains, falls substantially below that used for LEU fuel cores. Figure 3-3 shows a comparison of decay heat plus actinide heat for MOX fuel, the curve fit applied in the Framatome ANP evaluation model for LEU fuel, and the 1971 proposed ANS 5.1 Standard required by 10 CFR 50.46 Appendix K. The MOX fuel curve includes uncertainty factors sufficient to provide a 95 percent level of confidence that there is a 95 percent probability that the decay heat and the actinide heat are over-predicted. The Framatome ANP curve is a conservative fit to the 1971 proposed decay heat standard required by Appendix K. Both the Framatome ANP curve and the 1971 standard curve include a 20 percent increase in the decay heat and best-estimate actinide heat prediction.

The MOX fuel decay heat curve is consistently below the Framatome ANP LOCA evaluation model curve for the first 36,000 seconds (10 hours) and, except for times less than 0.1 seconds, consistently below the 1971 proposed ANS standard to 1,000 seconds. Beyond 1,000 seconds, there is no significant difference between the MOX fuel curve and the 1971 proposed standard. Integrating the decay and actinide powers, the total energy represented by the Framatome ANP curve up to the approximate time of peak cladding temperature, 150 to 400 seconds, averages more than 12 percent higher than the MOX fuel curve. Therefore, it is conservative to use the same decay and actinide heat rate for MOX fuel of the lead assembly design as was approved for LEU fuel. No change to the evaluation model is required for MOX fuel decay heat effects.

3.7.1.1.3 Thermal and Mechanical Properties

The MOX fuel thermal-mechanical properties are very similar to those for LEU fuel. Six primary fuel properties are used in LOCA evaluations: thermal expansion, thermal conductivity, specific heat, emissivity, elastic modulus, and Poisson's ratio. The COPERNIC fuel rod performance code (Reference 3) differentiates a MOX fuel correlation only for thermal conductivity.[4] For each of these physical properties, the MOX LOCA evaluations will be conducted with close approximations over the LOCA temperature range to the appropriate COPERNIC correlation (MOX or LEU).

3.7.1.1.4 Steady State Fuel Temperature Prediction

The Framatome ANP LOCA evaluation model requires that the initial fuel temperature for a LOCA simulation be determined by a NRC-approved fuel performance code. For LEU fuel Framatome ANP has typically used the TACO3 code as discussed in References 10 and 11. However, COPERNIC, a more recent Framatome ANP code has models capable of predicting MOX and LEU fuel performance. Accordingly, Framatome ANP has applied COPERNIC for the determination of the steady state performance of the MOX fuel lead assemblies and for the initialization of comparison LEU fuel calculations. The following subsections discuss the changes to the LOCA evaluation model necessitated by the adoption of COPERNIC for LOCA initialization.

<u>Transient Initialization</u>
The main effect on LOCA evaluations due to the change from TACO3 to COPERNIC is that the improved fuel conductivity model alters the RELAP5 fuel-to-clad gap initialization. With TACO3, the RELAP5 gap model was initialized at steady state. Agreement with TACO3 initial volume-averaged fuel temperature predictions was achieved by adjusting the multipliers on the gaseous conductance term coefficient. Multiplier values varied from 0.8 to 2.0. Although the multipliers were retained throughout the transient, they did not impose a significant change in the gap coefficient. With COPERNIC, an adjustment to only the gaseous conductance would require larger multipliers than are deemed appropriate for application throughout the LOCA transient. An alternative approach was chosen for the MOX fuel lead assembly analyses, specifically to initialize RELAP5 with the COPERNIC fuel temperatures and gaseous conductance multipliers of 1.0. The core model will not be in steady state at transient initiation but the gap coefficient will be appropriate for use during the transient. The lack of a time zero steady state is not consequential because the cladding response to a LOCA is a rapid heatup during the first one or two seconds of the transient. This causes the cladding to pull away from the pellet. Under this condition, the gaseous

[4] COPERNIC has been approved by NRC for use with UO_2 fuel. NRC review of COPERNIC for application to MOX fuel is underway with approval expected by January 2003.

conductance is the only significant contributor to the gap coefficient. Thus, the approach improves the gap modeling for the LOCA transient relative to the current EM. A sensitivity study documented in Section 3.7.1.3 shows that the effect on peak cladding temperature of changing the gaseous conductance by a factor of 2.0 is small.

Initial Fuel Temperature Uncertainty
The use of COPERNIC for LOCA initialization necessitates a determination of the initial fuel temperature uncertainties to be applied to the average core, the hot assembly, and the hot pin. The measured-to-predicted distribution for COPERNIC, Reference 12, demonstrates that a constant temperature increment should be added to COPERNIC predictions to assure that 95 percent of the data are bounded with 95 percent confidence at high temperatures. Thus, the LOCA simulation for the hot pin should be initialized at the COPERNIC prediction plus the incremental adjustment. Assuming that the uncertainty distribution for COPERNIC is approximately normal, the relationships between the hot pin, the hot bundle, and the average core initial temperature predictions developed for TACO3 in Reference 13 (and approved by the NRC in Reference 14) remain reasonable for application to COPERNIC predictions. TACO3 applications required that 11.5 percent be added to the hot pin initial temperature to assure a 95/95 prediction and that 3.0 percent be added to the hot assembly to assure a 95/95 confidence. The corresponding temperature adjustments for core initialization with COPERNIC are: 1) no adjustment of the COPERNIC prediction for the average core, 2) the hot assembly predicted temperature is increased by 26 percent of the COPERNIC incremental adjustment, and 3) the hot pin temperature is increased by the full COPERNIC incremental adjustment.

3.7.1.1.5 Plutonium Concentration in Fuel Pins

A MOX fuel lead assembly contains three regions or zones of fuel pins, with each region having a different plutonium concentration. The differing plutonium concentrations will have an effect on the material properties of the pin, as described in Section 3.7.1.1.3. This effect is explicitly modeled in the analyses described in Section 3.7.1.3, and the results indicate that the effect is negligible.

3.7.1.2 Evaluation Model Adjustments Required for Lead Assembly LBLOCA Calculations

This section describes the changes made to the approved Framatome ANP LBLOCA evaluation model (References 4 and 15) for use in MOX lead assembly calculations. The changes described are directly related to MOX fuel effects.

3.7.1.2.1 Adjustments for COPERNIC

The technique for the lead assembly LBLOCA calculations is altered as a result of the use of COPERNIC to specify initial fuel conditions. The alteration involves the initialization of RELAP5 with COPERNIC initial fuel temperatures without adjusting the fuel-to-clad gap coefficient to produce a thermal steady state condition. The fuel is in a transient condition at the start of the LOCA simulation. As discussed in Section 3.7.1.1.4, this approach offers the benefit of preserving the gaseous conductance term of the fuel-to-clad gap coefficient throughout the transient. Additionally, the initial fuel temperature uncertainty adjustments were altered as described in Section 3.7.1.1.4 to reflect the measured-to-predicted distribution from the COPERNIC benchmarks.

3.7.1.2.2 Adjustments for MOX Fuel Physical Properties

The approved evaluation model uses fuel materials properties characteristic of LEU fuel. The evaluation for the MOX fuel lead assemblies uses fuel materials properties based upon the COPERNIC code, which is under review for application to MOX fuel. Although these properties do not differ substantially between MOX and LEU fuel, the thermal conductivity correlation within COPERNIC (for LEU fuel or MOX fuel) is improved over the conductivity modeling previously incorporated in Framatome ANP evaluation models.

3.7.1.2.3 Rupture Modeling for Mid-Span Mixing Grids

This section describes how the approved fuel pin rupture model will be applied to fuel assemblies incorporating mid-span mixing grids (MSMGs - non-structural grids centered between structural grids). For the purpose of determining bundle blockage characteristics following cladding rupture, the Framatome ANP LOCA evaluation model assumes that the incidence of rupture is distributed throughout the upper two-thirds of the structural grid span within which rupture is calculated. For cores containing fuel assemblies with MSMGs, the modeling assumption is that the rupture density at the location of maximum blockage is not altered from that of a core containing no fuel assemblies with MSMGs. Rupture cooling is modeled in the hot assembly at only one elevation for cores with either type of grid configuration.

3.7.1.3 Representative LBLOCA Calculations

To provide validation of the expected LOCA results for the MOX fuel lead assemblies, a set of large break LOCA comparison cases for LEU and MOX fuel assemblies, both of the lead assembly design, were run. All cases simulated a full double-ended guillotine break at the cold leg pump discharge with a C_D of 1.0 and an initial power distribution peaked toward the core outlet (10.3-ft elevation). All cases incorporated the evaluation model adjustments described in Section 3.7.1.2, except as noted below for Case 2. The three cases are described below.

Case 1: MOX fuel base case with nominal gap conductance (See Section 3.7.1.2.1).
Case 2: MOX fuel case with 2.0 multiplier on nominal gap conductance.
Case 3: LEU fuel case otherwise identical to Case 1.

These calculations demonstrated that no significant difference exists between the two fuel types.

Table 3-2 lists the plant parameters and their values used in the calculations. As indicated in this table, the MOX fuel lead assemblies were held to a total peaking limit (F_Q) of 2.4, four percent lower than the limit for the resident LEU fuel. A sequence of events for Case 1, the base MOX fuel lead assembly calculation, is provided in Table 3-3. Table 3-4 shows the results for fuel pins of three differing plutonium concentrations representative of the MOX fuel lead assemblies.

Table 3-5 compares the base MOX fuel evaluation case (Case 1) with the same MOX fuel assembly initialized with a fuel-to-clad gaseous conductance coefficient multiplier of 2.0 (Case 2). Increasing the clad-pellet gaseous conductance coefficient to twice its value approximates the type of core initialization that is used when the initial fuel temperature is obtained from TACO3. The peak cladding temperature changes by about 13 degrees F. The comparison of the MOX fuel (Case 1) and the LEU fuel (Case 3) results show a difference of 37 degrees F. This is expected, given the relatively minor differences in the modeling of the two fuel types.

Figures 3-4 and 3-5 provide information about the evaluation model and the input models for these calculations. Figures 3-6 through 3-11 provide the time dependence for important LOCA parameters based on Case 1. Note that there are no essential differences in calculation results between LEU fuel and MOX fuel with the modeling assumptions and conservatisms used.

The conclusion from these comparison calculations is that:

1) The calculated LOCA performance of MOX fuel and LEU fuel is substantially unaffected by the difference in the fissionable isotope even when no credit is taken for the expected reduction in decay heat in MOX fuel,

2) The impact of the EM core initialization technique, removal of the forced thermal steady state requirement, is small, and

3) The effect of different plutonium concentrations on peak cladding temperature (PCT) is insignificant and need not be specifically modeled.

3.7.1.4 LBLOCA Analytical Basis for Operation

The LOCA analytical basis for operation of the lead assemblies will be developed during 2002 and early 2003. It is expected that the results will validate the allowed peaking employed in the sample calculations as shown in Table 3-2. The following calculations will be performed to validate lead assembly operability.

1) Time-in-Life (Burnup) Sensitivity Study to 60 GWd/MThm (assembly burnup)

2) Steam Generator Design Effects Study (Three of the four McGuire/Catawba units have replacement steam generators of slightly altered design and lower tube plugging.)

3) Power Distribution (LOCA Limits) Study to Validate K_Z

These calculations will employ the model adjustments as described in Section 3.7.1.2.

3.7.1.5 Small Break LOCA (SBLOCA) Evaluation

The primary SBLOCA issue is determining the core mixture level as a function of time. After such a determination is made, steam production below the mixture level is used with convection-to-steam and radiation heat transfer models to determine cladding temperatures above the mixture level. For the MOX fuel lead assembly core, the resident fuel assemblies dominate the core mixture level prediction, and the existing licensing calculations are applicable to the lead assemblies. Steam is rapidly diverted from the hot assembly to the average core to achieve a relatively uniform steam velocity across the core. Hence, the steam flow in the hot assembly at the location of the hot spot is characteristic of the average core flow and is essentially independent of the hot bundle power or configuration. Therefore, so long as the surface area for heat transfer or other local film coefficient effects are not altered, there will be no effect on the predicted cladding temperature between the lead assemblies and the resident LEU fuel assemblies. The lead assemblies have the same heat transfer surface area as the resident assemblies. The allowed local power of each MOX fuel lead assembly will not exceed that allowed for the resident fuel assemblies. Therefore, the calculated peak cladding temperatures for the lead assemblies will be less than those calculated for the resident fuel assemblies and it is appropriate for the lead assemblies to use the existing SBLOCA evaluation as their licensing basis.

3.7.1.6 Mixed Core Loading Effects

The MOX fuel lead assemblies will reside within a core of Westinghouse LEU fuel assemblies. The lead assemblies will be surrounded by resident LEU fuel assemblies having the same physical dimensions and very similar hydraulic characteristics. The MOX fuel lead assembly design employs MSMGs and the resident fuel design uses intermediate flow mixing grids (IFMs). The design of these mixing grids is such that the MOX fuel lead assembly pressure drop is less than four percent lower than the pressure drop for a resident Westinghouse fuel assembly at design flow rates. Hence, flow diversion favoring one fuel assembly at the expense of the other design is expected to be inconsequential. Therefore, there will be no mixed core impact on the LOCA performance of the resident Westinghouse assemblies. The complete set of lead assembly LOCA calculations will be done with the average core modeled to simulate the hydraulic performance of the resident assemblies, providing a direct evaluation of the resident fuel effects on the MOX fuel lead assemblies.

3.7.1.7 Conclusions

There are no significant differences in calculated LOCA performance between LEU and MOX fuel with the modeling assumptions and conservatisms selected. No adverse consequences due to the presence of four MOX fuel lead assemblies in the resident core of LEU fuel assemblies are expected. Therefore, during a postulated LOCA, the MOX fuel lead assemblies behave essentially the same as the resident LEU fuel assemblies and the calculations for the resident assemblies can be applied to the lead assemblies. However, the resident LEU fuel assemblies rely on a best estimate LOCA model as the licensing basis, and the calculations described herein were performed with a deterministic model. To reconcile this difference, the 95/95 bounding LOCA results for the resident assemblies are compared to the lead assembly representative results in Table 3-6. This table will be reconstructed when the final licensing basis calculations are performed. The differences between the calculation approaches and the assembly designs are identified within the table. These differences can, if necessary, be applied to future resident assembly calculations to establish the expected impact on the lead assemblies. This eliminates the need to perform calculations on both resident LEU fuel assemblies and the MOX fuel lead assemblies in the event that revised LOCA calculations are needed. If the need for recalculation specifically concerns the performance of the lead assemblies, specific lead assembly calculations will be made with the models described herein and the relationship between the resident fuel and MOX fuel lead assembly LOCA results reestablished.

3.7.2 Impacts of MOX Fuel Lead Assemblies on Non-LOCA Analyses

All of the non-LOCA transients and accident analyses described in Chapter 15 of the McGuire and Catawba UFSARs were reviewed to determine the impact of MOX fuel lead assemblies on the results and to verify that acceptance criteria continue to be met. In addition, the mass and energy release analyses in Chapter 6 of the UFSAR were also reviewed for any effect due to MOX fuel. Potential effects due to fuel assembly design differences are addressed in Section 3.7.2.2. The evaluation of MOX fuel effects resulting from changes in core average physics parameters is provided in Section 3.7.2.3. Some design bases transients and accidents are potentially sensitive to local physics parameters, and those are evaluated in Section 3.7.2.4. Potential decay heat effects are addressed in Section 3.7.2.5.

3.7.2.1 Transients and Accidents Evaluated

The transients and accidents evaluated and the associated UFSAR sections are listed below.

1) Mass and Energy Release Analysis for Postulated Loss-of-Coolant Accidents (6.2.1.3)
2) Mass and Energy Release Analysis for Postulated Secondary System Pipe Ruptures inside Containment (6.2.1.4)

3.9 REFERENCES

1. *MOX Fuel Design Report*, BAW-10238(NP), Revision 0, Framatome ANP, March 2002.

2. *Advanced Mark-BW Fuel Assembly Mechanical Design*, BAW-10239(P), Revision 0, Framatome ANP, March 2002.

3. *COPERNIC Fuel Rod Design Computer Code*, BAW-10231P, Revision 0, September 1999.

4. David B. Mitchell and Bert M. Dunn, *Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel*, BAW-10227P-A, February 2000.

5. Duke Power Company *Nuclear Design Methodology Using CASMO-4/ SIMULATE-3 MOX, DPC-NE-1005P*, August 2001.

6. Duke Power Company *McGuire/Catawba Core Thermal-Hydraulic Methodology Using VIPRE-01*, DPC-NE-2004P-A, Revision 1, February 1997.

7. Duke Power Company *Westinghouse Fuel Transition Report*, DPC-NE-2009P-A, September 1999.

8. Duke Power Company *Thermal-Hydraulic Statistical Core Design Methodology*, DPC-NE 2005P-A, Revision 3, 2002.

9. NUREG/CR-0200, CCC-545, *Modular Code System for Performing Standard Computer Analyses for Licensing Evaluation*, Oak Ridge National Laboratory, November 1993.

10. D.A. Wesley and K. J. Firth, *TACO3 – Fuel Pin Thermal Analysis Code*, BAW-10162PA, October 1989.

11. *Extended Burnup Evaluation,* BAW-10186PA, Revisions 1and 2, and "Supplement 1 to BAW-10186P Revision 1 Mark-BW Extended Burnup."

12. Letter Framatome ANP to U. S. Nuclear Regulatory Commission, Response to Request for Additional Information on BAW-10231P "COPERNIC Fuel Rod Design Code," Response to Question 3, February 5, 2001.

13. Letter Framatome Technologies to U.S. Nuclear Regulatory Commission, "Modeling Refinements to Framatome Technologies RELAP5-Based, Large Break LOCA Evaluation Models – BAW-10168 for Non-B&W-Designed, Recirculating Steam Generator Plants and BAW-10192 for B&W-Designed, Once-Through Steam Generator Plants," FTI-00-551, February 29, 2000.

14. Letter U. S. Nuclear Regulatory Commission to Framatome ANP, "Safety Evaluation of Framatome Technologies Topical Report BAW-10164P, Revision 4, "RELAP5/MOD2-B&W, An Advanced Computer Transient Analysis (TAC Nos. MA8465 and MA8568)," April 9, 2002.

15. *RSG LOCA - BWNT Loss-of-Coolant Accident Evaluation Model for Recirculating Steam Generator Plants*, BAW-10168PA, Revision 3, December 1996.

16. Duke Power Company *Thermal-Hydraulic Transient Analysis Methodology*, DPC-NE-3000-PA, Revision 2, December 2000.

17. Duke Power Company *Multidimensional Reactor Transients and Safety Analysis Physics Parameters Methodology*, DPC-NE-3001-PA, December 2000.

18. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC, 1988.

19. *Surplus Plutonium Disposition Final Environmental Impact Statement,* DOE/EIS-0283, U.S. Department of Energy, Office of Fissile Materials Disposition, November 1999.

Table 3-2

Plant Parameters and Operating Conditions Used In LOCA Evaluation

Parameter	Value
Reactor Power (MWt)	3411
Pressurizer Operating Pressure (psia)	2310
System Flow (gpm)	382,000
Hot Leg Temperature (degrees F)	616
Cold Leg Temperature (degrees F)	555
Core Average Linear Power Generation Rate* (kW/ft)	5.69
Highest Allowable Total Peaking for MOX Fuel Assembly (F_Q)	2.4
Hot Pin and Hot Assembly Radial Peaking Factors	1.60
Core Axial Peaking Factor	1.50

* Increased to include 102 percent of rated power

Table 3-3

Case 1 - Sequence of Events for MOX Fuel Lead Assembly Calculation

Event	Time (seconds)
Leak Initiation	0
Accumulator Injection Begins	12.8
End of Blowdown	25.3
Bottom of Core Recovery	39.7
Rupture in Hot Assembly	73
Peak Cladding Temperature (unruptured node)	130

Table 3-4

Plutonium Loading LOCA Results Comparison

Calculation Results	2.3 % Pu Pin	3.6 % Pu Pin	4.4 % Pu Pin
Peak Cladding Temperature (degrees F)	2018	2017	2017
PCT Location (ft)	8.8	8.8	8.8
Peak Cladding Temperature at Rupture Location (degrees F)	1841	1841	1841
Hot Pin Rupture Location (ft)	9.7	9.7	9.7
Hot Pin Rupture Time (sec)	73	73	73

Table 3-5

LBLOCA Sample Calculations Comparison

Results	Case 1 MOX Fuel	Case 2 MOX Fuel 2x Gap Factor	Case 3 LEU Fuel
Peak Cladding Temperature Data (Peak Pin Data)			
Peak Cladding Temp. (degrees F)	2018	2005	1981
PCT Location (ft)	8.8	8.8	8.8
Rupture Node Data			
Peak Temperature at Rupture Location (degrees F)	1841	1783	1753
Hot Pin Rupture Location (ft)	9.7	9.7	9.7
Hot Pin Rupture Time (sec)	73	73	71
Oxidation Data			
Max. Local Oxidation* (percent)	4.5	4.6	4.0
Location of Max. Oxidation (ft)	8.8	8.8	8.8

* Local Oxidation at the end of 400 second simulation.

Table 3-6

Comparison of Resident Fuel LOCA Calculation to MOX Fuel Calculation

	MOX Fuel	Resident Fuel (95 percentile)	Difference
Highest Allowable Total Peaking (F_Q)	2.4	2.5	-0.1
Peak Cladding Temperature (degrees F)	2018	2056	-38
Maximum Local Oxidation* (percent)	4.5	10	-5.5

*After 400 seconds

Figure 3-2
Reactivity Insertion versus Void Fraction
Infinite Lattice UO_2 at MTC = 0.0 pcm/degree F

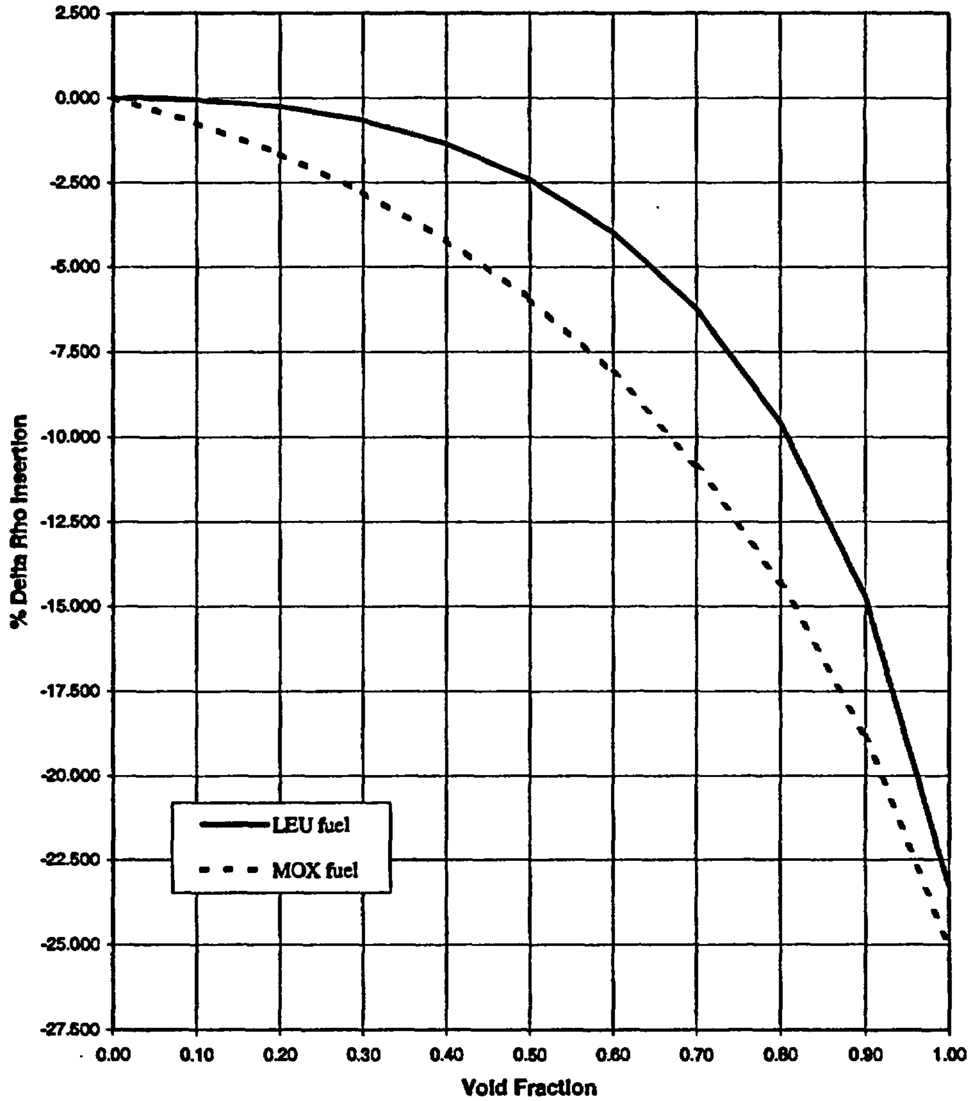


Figure 3-3
Decay Heat Rate Comparisons
MOX and LEU Fuel Fission Products plus Actinides

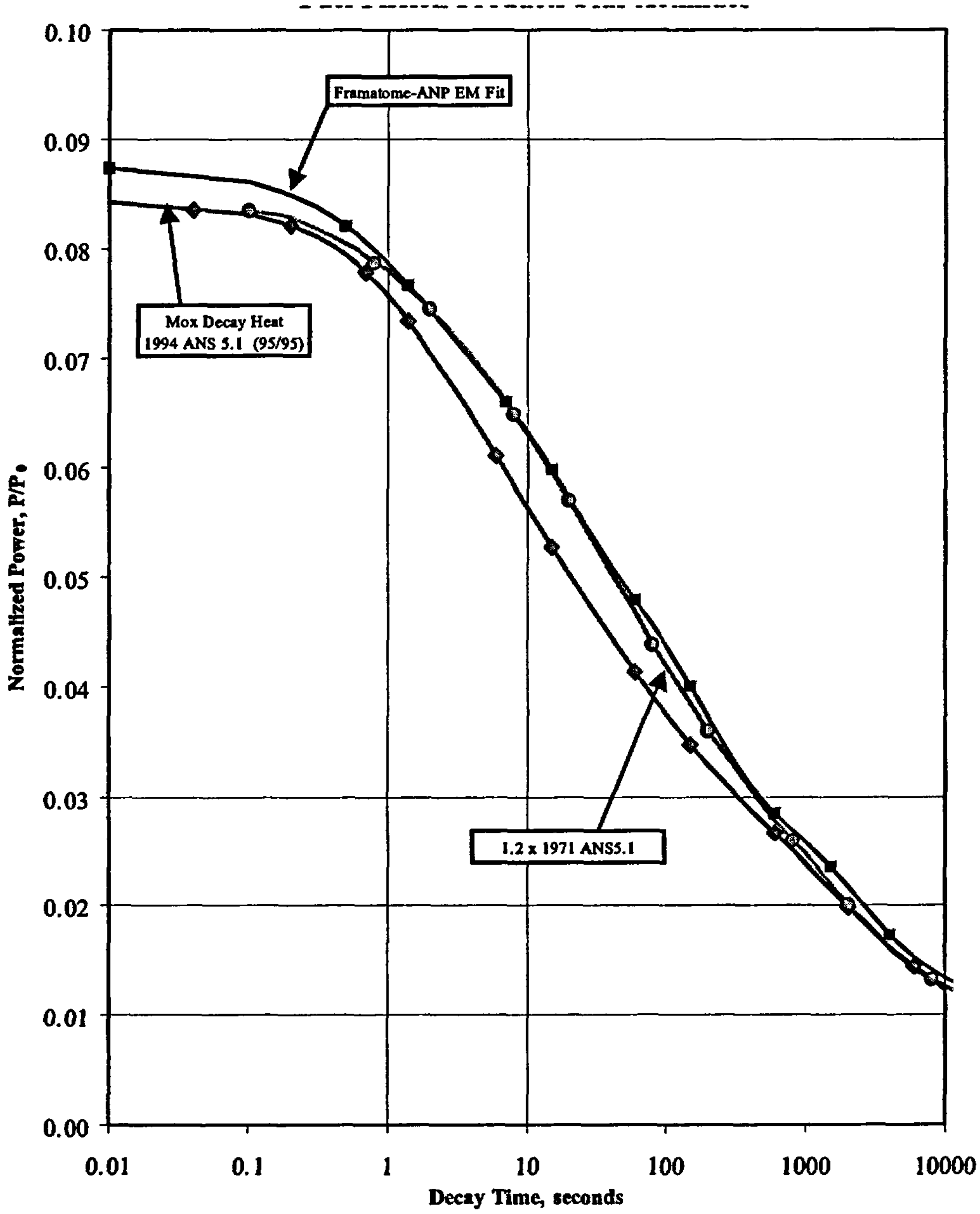
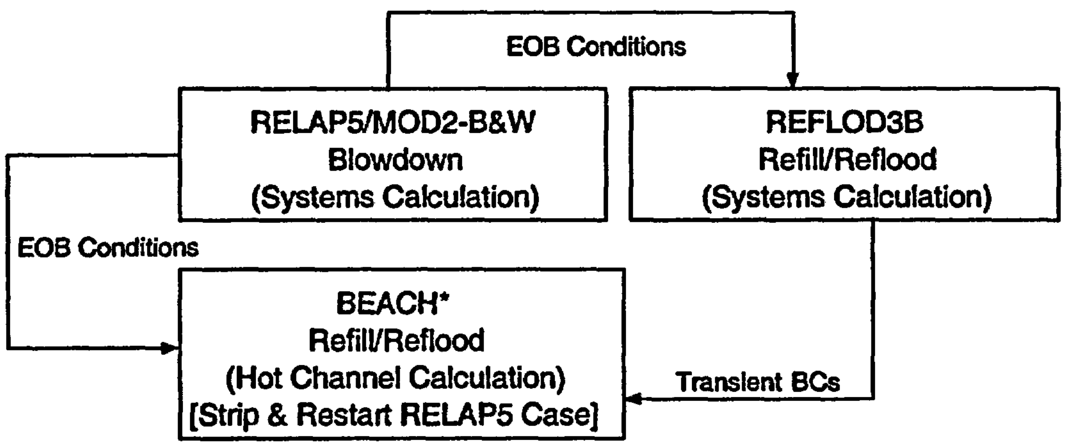


Figure 3-4
Framatome ANP Recirculating Steam Generator
LOCA Evaluation Model Codes



*BEACH is a set of reflood heat transfer subroutines in RELAP5.

Figure 3-5
RELAP5/BEACH Core Noding with Mid Span Mixing Grids

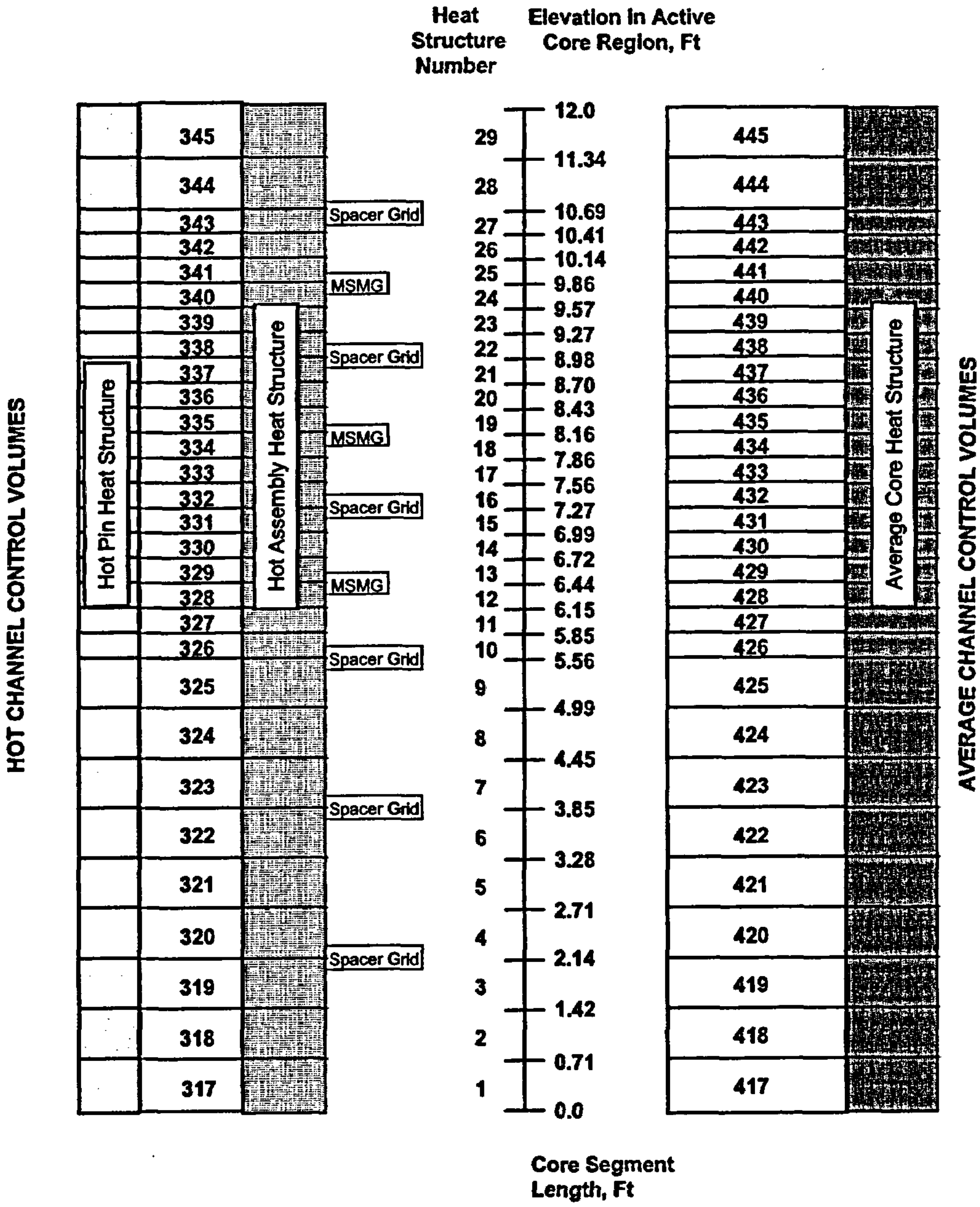


Figure 3-6
RCS Pressure for MOX LOCA Calculations during Blowdown (10.3 ft Axial Peak)

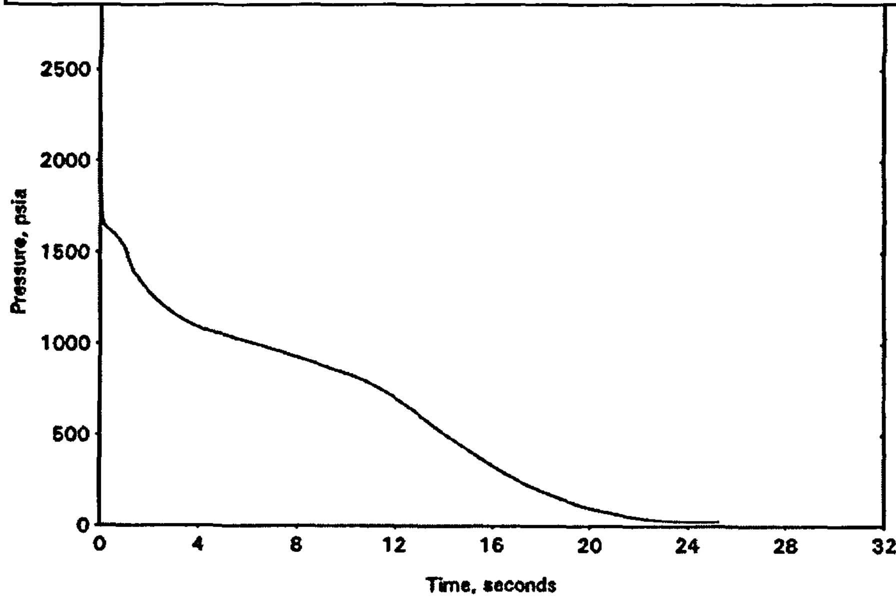


Figure 3-7
Reflooding Rate for MOX LOCA Calculations (10.3 ft Axial Peak)

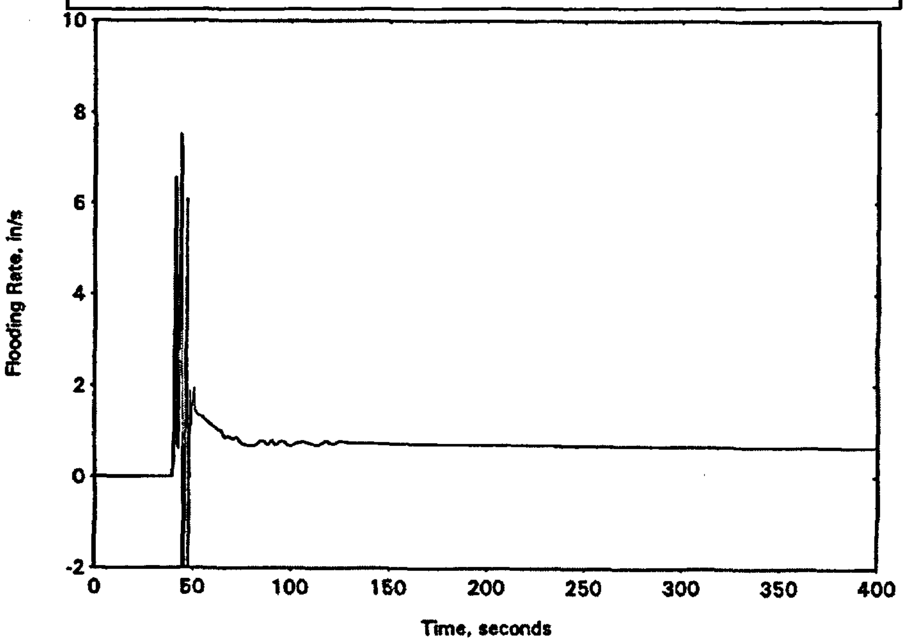


Figure 3-8
Fuel to Clad Gap Multiplier Study Results (10.3 ft Axial Peak)

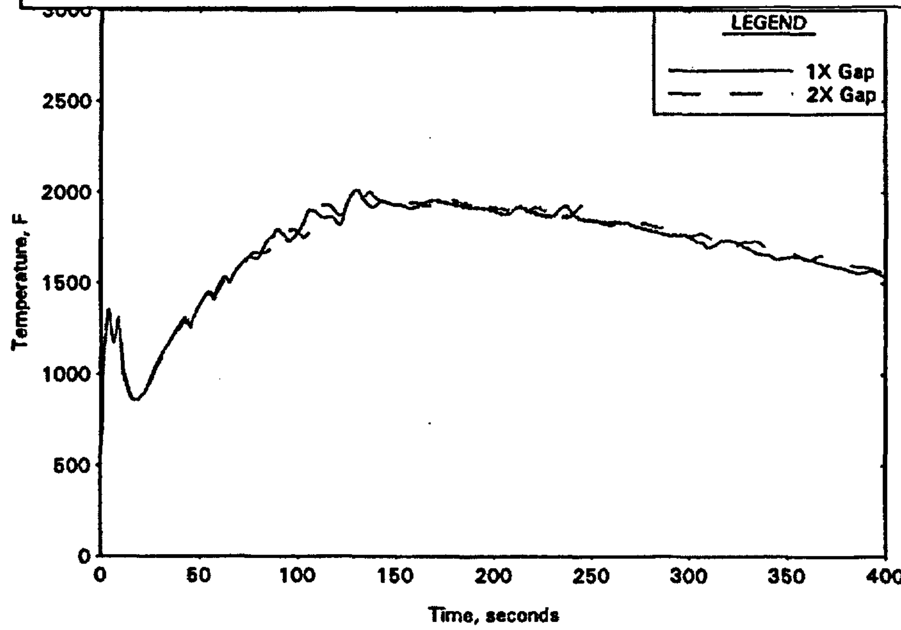


Figure 3-9
Fuel to Clad Gap Multiplier Study
Ruptured Node Results (10.3 ft Axial Peak)

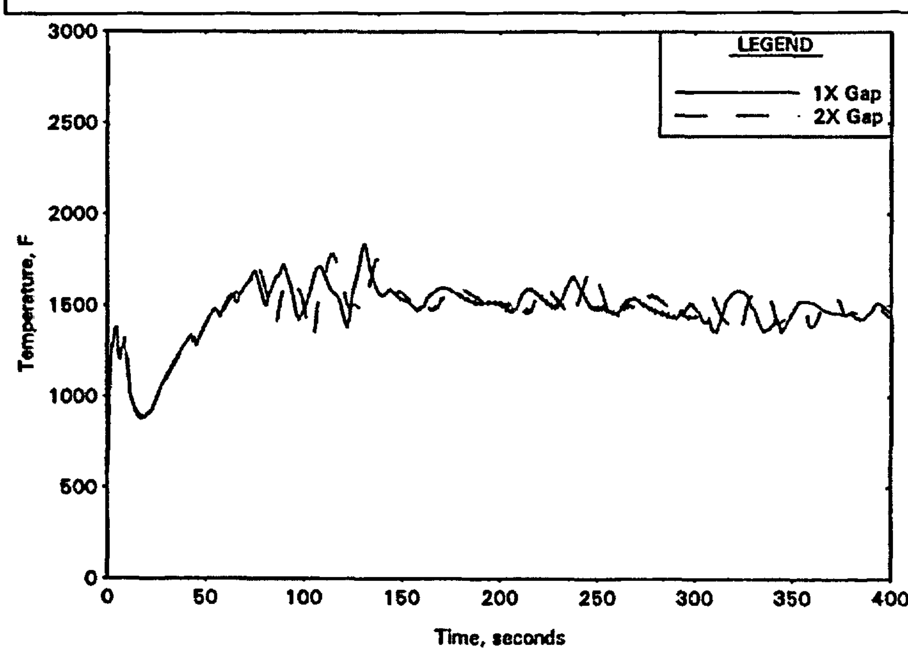


Figure 3-10
Hot Pin PCT MOX Lead Assembly vs. LEU Assembly (10.3 ft Axial Peak)

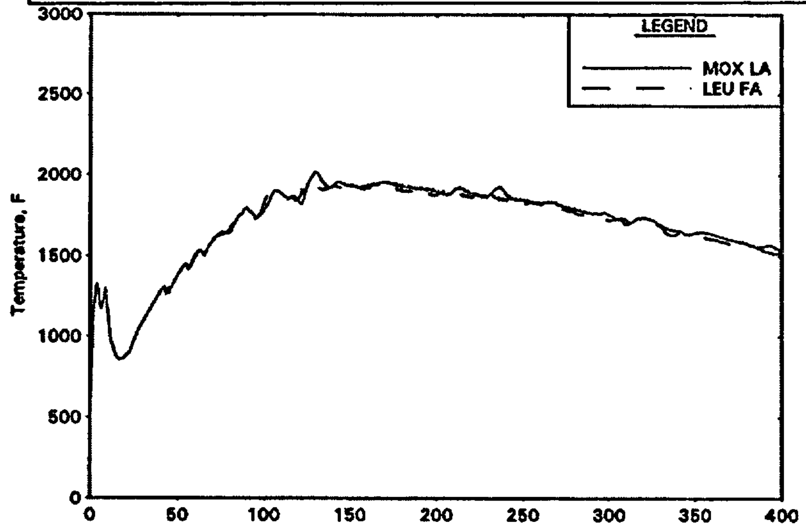


Figure 3-11
Hot Pin Ruptured Location PCT MOX Lead Assembly vs. LEU Assembly (10.3 ft Axial Peak)