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PREDICTIONS AND ACCEPTANCE CRITERIA FOR K REACTOR STARTUP AND POWER ASSESSMENT (U)

by

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JUNE 1991

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REACTOR ENGINEERING DEPARTMENT**

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REACTOR ENGINEERING DEPARTMENT**

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KEYWORDS:
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**PREDICTIONS AND ACCEPTANCE CRITERIA FOR
K REACTOR STARTUP AND POWER ASCENSION (U)**

BY:

R. A. BOND, JR.

ISSUED: June 4, 1991

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June 4, 1991

PREDICTIONS AND ACCEPTANCE CRITERIA FOR K REACTOR STARTUP AND POWER ASCENSION (U)

INTRODUCTION

The master procedure to startup K Reactor is RSP 90-007. Within this procedure are 16 separate tests to verify that the reactor will be operated within the parameters described in the Safety Analysis Report (SAR), Safety Evaluation Report (SER), and Technical Specifications. Several of these tests will provide data to benchmark reactor physics computer codes that are used in core design and safety analysis. RSP 90-007 applies acceptance criteria or expectation ranges to results of measurements performed in each test. Calculations for the predictions have been performed by various members of Reactor Technology in the Reactor Engineering Department and Reactor Physics of Savannah River Laboratory. This technical report combines all predictions and acceptance criteria into one document.

SUMMARY

The purpose of this report is to consolidate all the work performed on the predictions and acceptance criteria for the K Reactor Startup and Power Ascension Test Program. All results reported in this document are referenced to technical documents. This report consolidates the results of several technical reports previously issued. The technical background of the results can be found in the references given in this document.

DISCUSSION

This discussion briefly describes the predictions and acceptance criteria of each test. The individual tests are discussed and referenced separately.

Section 1: RSP 90-007-1 Radiation Surveys

Radiation surveys will be performed in the 105 K Building at the following times:

- 1) Before startup to provide baseline measurement
- 2) At 75 MW during the initial power ascension
- 3) At 90% power during the initial power ascension
- 4) During full power operation, after one month of full power production operation.

Acceptance Criteria: No radiation readings will exceed current postings in the following areas:

Clean areas

Radiation areas

High radiation areas

Very high radiation areas

Contamination areas

Airborne radioactivity areas

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #1, November 7, 1990.

DPSOP 40-1, Rev. 24, SRP Radiation and Contamination Control.

DPSOL 193-118, Radiological Posting.

Section 2: RSP 90-007-2 Safety Rod System Testing

This test will functionally test the safety rod system to verify operability and safety rod insertion timing.

Acceptance Criteria: Limits as defined in the following DPSOLs:

DPSOL 105-1218 Safety Rod Snubbing Height Test

DPSOL 105-1046D Nuclear Startup - Raising Safety Rods - Manual Control: Section B - Safety Rod Drop Test

DPSOL 105-1863A Safety Rod Insertion Time Determination

DPSOL 105-1213 Safety Rod Snubber Deformation Test

DPSOL 105-1046H and I Nuclear Startup - Data Operator Duties, Section B - Raising Safety Rods

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #2, November 7, 1990.

DPSOL 105-1218 Safety Rod Snubbing Height Test

DPSOL 105-1046D Nuclear Startup - Raising Safety Rods - Manual Control Section B - Safety Rod Drop Test

DPSOL 105-1863A Safety Rod Insertion Time Determination

DPSOL 105-1213 Safety Rod Snubber Deformation Test

DPSOL 105-1046H and I Nuclear Startup - Data Operator Duties, Section B - Raising Safety Rods

Section 3: RSP 90-007-3 Initial Critical

The primary objective is to start up the reactor, approaching critical in a slow, cautious, and deliberate manner. After the reactor is critical, the reactor will be operated in the 40 KW to 120 KW power range to determine the stability of the reactor at this low power.

Predictions: Estimated Critical Position - 2260 vu

Acceptance Criteria: Allowable insertion limits for approach to criticality and operator actions if limits are exceeded are described in DPSOL 105-1060, Charge Reactivity Assessment.

Limits for critical position

Maximum Insertion at Critical - 3275 vu

High Critical Position - 2615 vu

Low Critical Position - 1650 vu

Minimum Insertion at Critical - 1170 vu

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #3, February 21, 1991.

Swingle, R. F., Core Operations Report - Physics, RTM-5000-K-14-1, June 1991.

Section 4: RSP 90-007-4 Reactivity Computer Calibration

This test will be performed while the reactor is at zero power (40 to 120 KW range) to verify that the reactivity computer is properly calculating reactivity changes. Reactivity changes of 20 pcm and 45 pcm (percent millirho or $10^{-5} \Delta k/k_{eff}$) will be made. The reactivity change calculated by the computer in real time will be compared to the reactivity change calculated by the inhour equation using a known reactor period. Given the rate of change in neutron flux, the reactivity computer calculates reactivity with the inverse kinetics equation. The inhour equation is a static calculation using the reactor period to calculate reactivity.

Acceptance Criteria: Deviation between reactivity value from reactivity computer and reactivity value from measured period is 5% or less.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #4, February 6, 1991.

Section 5: RSP 90-007-5 Differential Control Rod Worth

A differential control rod worth is defined as the reactivity change from a steady state caused by the movement of a control gang. This test will be performed at zero power and the reactivity computer will be used to measure the effect of moving individual control rod gangs. The measurement of the reactivity changes associated with control rod gang moves with the reactivity computer will provide data to validate and improve the predicted control rod worth curves for the Mark 22 charge. Differential measurements will be performed with the following partial rod complements:

- 1) Double partial control rods at 800 vu
- 2) Double partial control rods at 950 vu
- 3) Double partial control rods at 700 vu
- 4) Weak partial control rods at 800 vu
- 5) Weak partial control rods at 950 vu
- 6) Weak partial control rods at 700 vu

Predictions: Critical rod positions for the cases 2 - 6 are determined using Figures 1 - 6 and the known critical rod position for double partial rods at 800 vu. Once the critical rod position is known during the first startup, the relative critical eigenvalue determined on Figure 1 will be used to determine the predicted critical rod position for the other cases (Figures 2 - 6) with different partial rod complements and locations.

Figures 7 - 12 describe the reactivity change caused by a 50 vu full control rod gang withdrawal. The maximum full rod gang withdrawal specified in RSP 90-007-5 will be 50 vu. These figures will be used if only a 50 vu full rod withdrawal must be made.

Expected gang full rod moves to obtain 10, 20, and 30 pcm reactivity changes have been calculated based on full rod positions (Figures 13 - 51).

Acceptance Criteria: For the measurements performed with the partial rods at 800 vu (both doubles and weaks), the reactivity changes as measured by the reactivity computer should be within 30% of the expected reactivity value. No acceptance criteria are provided for the cases with partial rods at 700 vu and 950 vu because rod worth curves are specifically calculated for partial rods located at 800 vu. Data with the partial rods at other axial positions will be used to validate and improve control rod worth curves over an extended range.

The critical rod positions for the cases 2 - 6 will be within $\pm 0.0071 \Delta k$ of the critical position predicted from Figures 1 - 6 after the first nuclear startup.

Section 5: (cont.)

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #5, February 5, 1991.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Rosser, M. A., Mark 22 Initial Critical Rod Worth Curves (U), WSRC-TR-91-42-033, May 1991.

Zino, J. F. and Nadeau, M. L., Reactivity Assessment Manual - Mark 22 Charge, WSRC-TR-90-42-057, Rev. 1. June 25, 1990.

Section 6: RSP 90-007-6 Detect Unlatched Control Rod with Reactivity Computer

No quantitative acceptance criteria or expectation values for this test.

Section 7: RSP 90-007-7 Single Partial Rod Insertion at Zero Power

This test will be performed at zero power to provide baseline data on the reactivity change caused by the insertion of a partial rod from its demand position to full in. The information will be used to analyze the dropped partial rod accident. The strong partial and weak partial rod will be individually inserted in the following clusters:

Cluster 1 - strong partial (rod F), weak partial (rod C)

Cluster 36 - strong partial (rod E), weak partial (rod B)

Cluster 52 - strong partial (rod C), weak partial (rod F)

Predictions: Expected reactivity changes caused by the insertion of single partial rods from 800 vu to 1000 vu for given full rod positions are shown in Figures 52 - 57.

Acceptance Criteria: The reactivity changes as measured by the reactivity computer should be within the maximum and minimum ranges of the expected reactivity values (Figures 52 -57). Reactivity worth of single partial rods will be verified to be less than 113 pcm, which is determined to be the maximum worth of a partial rod insertion incident in the Safety Analysis Report.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #7, February 7, 1991.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Final Draft Non-LOCA Sections for K Restart SAR, Chapter 15 (U), SRL-SAG-900551.

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JUNE 1991

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12/10/91

**REACTOR TECHNOLOGY SECTION
REACTOR ENGINEERING DEPARTMENT**

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ISSUED: June 4, 1991

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PREDICTIONS AND ACCEPTANCE CRITERIA FOR K REACTOR STARTUP AND POWER ASCENSION (U)

INTRODUCTION

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DPSOL 105-1863A Safety Rod Insertion Time Determination

DPSOL 105-1213 Safety Rod Snubber Deformation Test

DPSOL 105-1046H and I Nuclear Startup - Data Operator Duties, Section B - Raising Safety Rods

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #2, November 7, 1990.

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DPSOL 105-1863A Safety Rod Insertion Time Determination

DPSOL 105-1213 Safety Rod Snubber Deformation Test

DPSOL 105-1046H and I Nuclear Startup - Data Operator Duties, Section B - Raising Safety Rods

Section 3: RSP 90-007-3 Initial Critical

The primary objective is to start up the reactor, approaching critical in a slow, cautious, and deliberate manner. After the reactor is critical, the reactor will be operated in the 40 KW to 120 KW power range to determine the stability of the reactor at this low power.

Predictions: Estimated Critical Position - 2260 vu

Acceptance Criteria: Allowable insertion limits for approach to criticality and operator actions if limits are exceeded are described in DPSOL 105-1060, Charge Reactivity Assessment.

Limits for critical position

Maximum Insertion at Critical - 3275 vu

High Critical Position - 2615 vu

Low Critical Position - 1650 vu

Minimum Insertion at Critical - 1170 vu

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #3, February 21, 1991.

Swingle, R. F., Core Operations Report - Physics, RTM-5000-K-14-1, June 1991.

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Acceptance Criteria: Deviation between reactivity value from reactivity computer and reactivity value from measured period is 5% or less.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #4, February 6, 1991.

Section 5: RSP 90-007-5 Differential Control Rod Worth

A differential control rod worth is defined as the reactivity change from a steady state caused by the movement of a control gang. This test will be performed at zero power and the reactivity computer will be used to measure the effect of moving individual control rod gangs. The measurement of the reactivity changes associated with control rod gang moves with the reactivity computer will provide data to validate and improve the predicted control rod worth curves for the Mark 22 charge. Differential measurements will be performed with the following partial rod complements:

- 1) Double partial control rods at 800 vu
- 2) Double partial control rods at 950 vu
- 3) Double partial control rods at 700 vu
- 4) Weak partial control rods at 800 vu
- 5) Weak partial control rods at 950 vu
- 6) Weak partial control rods at 700 vu

Predictions: Critical rod positions for the cases 2 - 6 are determined using Figures 1 - 6 and the known critical rod position for double partial rods at 800 vu. Once the critical rod position is known during the first startup, the relative critical eigenvalue determined on Figure 1 will be used to determine the predicted critical rod position for the other cases (Figures 2 - 6) with different partial rod complements and locations.

Figures 7 - 12 describe the reactivity change caused by a 50 vu full control rod gang withdrawal. The maximum full rod gang withdrawal specified in RSP 90-007-5 will be 50 vu. These figures will be used if only a 50 vu full rod withdrawal must be made.

Expected gang full rod moves to obtain 10, 20, and 30 pcm reactivity changes have been calculated based on full rod positions (Figures 13 - 51).

Acceptance Criteria: For the measurements performed with the partial rods at 800 vu (both doubles and weaks), the reactivity changes as measured by the reactivity computer should be within 30% of the expected reactivity value. No acceptance criteria are provided for the cases with partial rods at 700 vu and 950 vu because rod worth curves are specifically calculated for partial rods located at 800 vu. Data with the partial rods at other axial positions will be used to validate and improve control rod worth curves over an extended range.

The critical rod positions for the cases 2 - 6 will be within $\pm 0.0071 \Delta k$ of the critical position predicted from Figures 1 - 6 after the first nuclear startup.

Section 5: (cont.)

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #5, February 5, 1991.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Rosser, M. A., Mark 22 Initial Critical Rod Worth Curves (U), WSRC-TR-91-42-033, May 1991.

Zino, J. F. and Nadeau, M. L., Reactivity Assessment Manual - Mark 22 Charge, WSRC-TR-90-42-057, Rev. 1. June 25, 1990.

Section 6: RSP 90-007-6 Detect Unlatched Control Rod with Reactivity Computer

No quantitative acceptance criteria or expectation values for this test.

Section 7: RSP 90-007-7 Single Partial Rod Insertion at Zero Power

This test will be performed at zero power to provide baseline data on the reactivity change caused by the insertion of a partial rod from its demand position to full in. The information will be used to analyze the dropped partial rod accident. The strong partial and weak partial rod will be individually inserted in the following clusters:

Cluster 1 - strong partial (rod F), weak partial (rod C)

Cluster 36 - strong partial (rod E), weak partial (rod B)

Cluster 52 - strong partial (rod C), weak partial (rod F)

Predictions: Expected reactivity changes caused by the insertion of single partial rods from 800 vu to 1000 vu for given full rod positions are shown in Figures 52 - 57.

Acceptance Criteria: The reactivity changes as measured by the reactivity computer should be within the maximum and minimum ranges of the expected reactivity values (Figures 52 -57). Reactivity worth of single partial rods will be verified to be less than 113 pcm, which is determined to be the maximum worth of a partial rod insertion incident in the Safety Analysis Report.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #7, February 7, 1991.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Final Draft Non-LOCA Sections for K Restart SAR, Chapter 15 (U), SRL-SAG-900551.

Section 8: RSP 90-007-8 Power Coefficient Data - Power Ascension

This test will assess the temperature and fission product reactivity feedback components as power is increased. Power levels for K Reactor will be as follows:

Zero power (40 KW - 120 KW)
Low power (75 MW)
20%, 40%, 60%, 90%, and 100% of current full power.

Reactivity effects of temperature and fission products will be determined using control rod positions and rod worth curves.

Predictions: Expected reactivity changes caused by temperature change as power is increased are shown in Figures 58 and 59. Figure 59 is used to determine the change in reactivity for a change in power from one power level to the next. The expected reactivity changes caused by fission product build-in during power ascension are shown in Tables 1 and 2. The expected reactivity changes caused by combined temperature and fission product effects are shown in Tables 3 and 4.

The fission product build-in shown in Tables 1 - 4, assume that the reactor is maintained at 20%, 40%, and 90% powers for 48 hours. Tables 1 and 3 assume that the reactor is operated at 60% power for one week for testing (Tests 10, 11, 12, and 14). Tables 2 and 4 assume the reactor is operated at 60% power for three weeks.

Acceptance Criteria: The reactivity changes as determined by control rod positions and rod worth curves should be within the maximum and minimum ranges of the expected reactivity values (Figures 58 and 59, and Tables 3 and 4).

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #8, November 7, 1991.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Henrikson, D. J., Fission Product Reactivity for Initial K-14 Power Ascension (U), RRD-RTS-910177, June 1991.

Rosser, M. A., Mark 22 Initial Critical Rod Worth Curves (U), WSRC-TR-91-42-033, May 1991.

Swingle, R. F., At-Power and Recovery Startup Control Rod Worth Curves for The K-14-1 Subcycle (U), WSRC-TR-91-42-046, May 30, 1991.

Rosser, M. A., Predicting Δk Held in Temperature For K Reactor Mark 22 Charges (U), WSRC-TR-90-42-120, October 22, 1990.

Section 9: RSP 90-007-9 Radial and Axial Power Distributions

At each power level from 75 MW and up, measurements of the radial and axial power shape will be made with the control computer. At 20% power with all full rods at the same insertion and double partial rods at 800 vu, radial and axial power shapes will be compared to calculated shapes. The 20% power level was chosen for radial and axial shape comparisons because the power will be low enough that full rods and partial rods can still be maintained at the same insertion in each gang and satisfy Tech Spec limits on power shapes. As power is increased above 20%, control rods will be adjusted to maintain the radial and axial power shapes within procedural limits. Determinations of reactivity held in control rods before and after power shape flattening at each power level will be made using control rod worth curves.

Predictions: Expected normalized and gang averaged radial power shapes based on full rod positions at 20% power are shown in Table 5. Expected normalized axial power shapes based on full rod positions at 20% power are shown in Table 6.

Acceptance Criteria: The radial power will be normalized to gang 1 average power as determined by gang averaged power from the control computer (program 22). For a given full rod position, the radial power distribution should be within the limits shown in Table 5. The limits are defined as $\pm 10\%$ of the normalized radial power for gangs 1 and 2 and $\pm 20\%$ of the normalized radial power for gang 3 and the buckled zone.

The normalized axial power shape as determined by the control computer (programs 15 and 40) should be within the limits given in Table 6. The limits are defined as $\pm 35\%$ of the normalized axial power shape for the given full rod position.

The allowable difference in reactivity worth held in control rods before and after flattening is $0.005 \Delta k/k_{eff}$.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #9, November 7, 1991.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Losey, D. C., Axial Power Shape Predictions for K-14 Startup (U), WSRC-TR-91-42-047, June 1991.

Rosser, M. A., Mark 22 Initial Critical Rod Worth Curves (U), WSRC-TR-91-42-033, May 1991.

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Section 9: (cont.)

References: Swingle, R. F., At-Power and Recovery Startup Control Rod Worth Curves for The K-14-1 Subcycle (U), WSRC-TR-91-42-046, May 30, 1991.

Losey, D. C., Limiting Axial Flux Shapes and Rod Worth Curves (U), RRD-RTS-910175, May 31, 1991.

Section 10: RSP 90-007-10 Integral Rod Insertion at 60% Power

This test will provide information for the analysis of the single rod withdrawal accident. The measurements will provide data about the reactivity change for an integral rod and an associated power perturbation. The change in reactivity will be measured using full control rod positions and control rod worth curves. The strong lithium (2.02 gm/ft Li-6) full control rod will be inserted as an integral rod in the following clusters:

Cluster 3 - Control rod C

Cluster 20 - Control rod A

Cluster 54 - Control rod E

Predictions: Expected reactivity changes caused by the insertion of a single integral rod are shown in Figures 60 - 64.

The rod configuration used for these predictions assume that with double partial rods at 800 vu, the gang 3 full rods will probably be at 100 vu. Calculations indicate for a radially flattened power shape gang 3 full rods will be at 100 vu, which is the minimum insertion for full control rods. Other calculations were performed to show the effects of gang 3 full rods being located at 450 vu and 1000 vu. The calculations primarily studied the effects of gang 1 and gang 2 full rod positions. The prediction made for the insertion of an integral rod in gang 3 is dependent on the gang 2 full rod position with gang 3 full rods at 100 vu, 450 vu, or 1000 vu. If the gang 3 full rods are not at these full rod locations, interpolation between the curves may have to be required.

Acceptance Criteria: There are no acceptance criteria for this test.

The change in reactivity as measured by control rod positions before and after the insertion of the single integral control rod should be within the range shown in Figures 60 - 64.

If the measured values are outside the expected range, an assessment will be made before continuing to next test. The expected values are based on the assumption that the double partial rods are located at 800 vu. If the power shape limits do not permit the control rod configuration used in the predictions, the measurements will probably not be within the ranges defined for this test.

Section 10: (cont.)

- References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #10, December 12, 1990.
- Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.
- Rosser, M. A., Mark 22 Initial Critical Rod Worth Curves (U), WSRC-TR-91-42-033, May 1991.
- Swingle, R. F., At-Power and Recovery Startup Control Rod Worth Curves for The K-14-1 Subcycle (U), WSRC-TR-91-42-046, May 30, 1991.

Section 11: RSP 90-007-11 Single Partial Rod Insertion at 60% Power

This test will provide baseline data on the reactivity worth and power distribution perturbation associated with the insertion of a single partial rod from its demand position to full in. The information will be used to analyze the dropped partial rod accident. This test will use same partial rods used in Test 7.

Predictions: Expected reactivity changes caused by the insertion of a single partial control rod are shown in Figures 65 - 82.

The rod configuration used for these predictions assume that with double partial rods at 800 vu, the gang 3 full rods will probably be at 100 vu. Calculations indicate for a radially flattened power shape gang 3 full rods will be at 100 vu, which is the minimum insertion for full control rods. Other calculations were performed to show the effects of gang 3 full rods being located at 450 vu and 1000 vu. The calculations primarily studied the effects of gang 1 and gang 2 full rod positions. The predictions made for the insertion of single partial rods in gang 3 are dependent on the gang 2 full rod position with gang 3 full rods at 100 vu, 450 vu, or 1000 vu. If the gang 3 full rods are not at these full rod locations, interpolation between the curves may have to be required.

Acceptance Criteria: There are no acceptance criteria for this test.

The change in reactivity as measured by control rod positions before and after the insertion of the single partial control rod should be within the range shown in Figures 65 - 82. Reactivity worth of single partial rods will be verified to be less than 113 pcm, which is determined to be the maximum worth of a partial rod insertion incident in the Safety Analysis Report.

If the measured values are outside the expected range, an assessment will be made before continuing to next test. The expected values are based on the assumption that the double partial rods are located at 800 vu. If the power shape limits do not permit the control rod configuration used in the predictions, the measurements will probably not be within the ranges defined for this test.

Section 11: (cont.)

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #11, December 20, 1990.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Rosser, M. A., Mark 22 Initial Critical Rod Worth Curves (U), WSRC-TR-91-42-033, May 1991.

Swingle, R. F., At-Power and Recovery Startup Control Rod Worth Curves for The K-14-1 Subcycle (U), WSRC-TR-91-42-046, May 30, 1991.

Final Draft Non-LOCA Sections for K Restart SAR, Chapter 15 (U), SRL-SAG-900551.

Section 12: RSP 90-007-12 Partial Rod Gang Positioning

This test will provide baseline data on the reactivity effect and power distribution perturbation caused by the insertion of a partial rod gang 50 vu from its normal demand position.

Predictions: Expected reactivity changes caused by the insertion of a double partial control rod gang are shown in Figures 83 - 91.

The rod configuration used for these predictions assume that with double partial rods at 800 vu, the gang 3 full rods will probably be at 100 vu. Calculations indicate for a radially flattened power shape gang 3 full rods will be at 100 vu, which is the minimum insertion for full control rods. Other calculations were performed to show the effects of gang 3 full rods being located at 450 vu and 1000 vu. The calculations primarily studied the effects of gang 1 and gang 2 full rod positions. The prediction made for the insertion of the double partial rod gang in gang 3 is dependent on the gang 2 full rod position with gang 3 full rods at 100 vu, 450 vu, or 1000 vu. If the gang 3 full rods are not at these full rod locations, interpolation between the curves may have to be required.

Acceptance Criteria: There are no acceptance criteria for this test.

The change in reactivity as measured by control rod positions before and after the insertion of a double partial control rod gang should be within the range shown in Figures 83 - 91.

If the measured values are outside the expected range, an assessment will be made before continuing to next test. The expected values are based on the assumption that the double partial rods are located at 800 vu. If the power shape limits do not permit the control rod configuration used in the predictions, the measurements will probably not be within the ranges defined for this test.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #12, January 23, 1991.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Rosser, M. A., Mark 22 Initial Critical Rod Worth Curves (U), WSRC-TR-91-42-033, May 1991.

Swingle, R. F., At-Power and Recovery Startup Control Rod Worth Curves for The K-14-1 Subcycle (U), WSRC-TR-91-42-046, May 30, 1991.

RSP 90-007-13 (Test deleted by Startup Testing Review Committee)

Section 13: RSP 90-007-14 Axial Power Monitor (APM) - Travelling Wire Flux Monitor (TWFM) Comparison

This test will collect data for an analysis assessing the response of the new Axial Power Monitor (APM) Rods. Axial power measurements with the APM rods will be compared with axial neutron flux measurements taken with the Travelling Wire Flux Monitor (TWFM).

Acceptance Criteria: The weighted variance between the normalized data from each TWFM trace and the normalized data from the corresponding APM rod should be less than 0.1 (10%).

Power cannot be increased above the Power Shape Applicability Limit (PSAL) if the deviations exceed 10% until the discrepancy has been resolved.

References: WSRC-TR-90-29-004K, Restart Test Identification Report #4, K-Reactor Power Ascension (U), Outline #14, January 17, 1991.

Losey, D. C., Startup Testing of New APM Rods (U), OPS-RTS-900093, July 1990.

Vescovi, P. J., Acceptance Criteria for Axial Power Monitor (APM) Testing (U), RRD-RTS-910090, Rev. 1, April 19, 1991.

Section 14: RSP 90-007-15 Safety Rod SCRAM Via Remote Monitoring and Control System (REMACS)

This test will demonstrate the capability of the REMACS system to remotely shut down K Reactor and demonstrate the shutdown capability of the safety rod system. Comparisons will be made of the relative neutron flux shape during the SCRAM with predictions based on safety rod worth used in the Safety Analysis Report.

Predictions: Expected decrease in relative flux caused by a safety rod SCRAM is shown in Figure 92.

Acceptance Criteria: The observed relative flux as measured by neutron flux detectors will decrease greater and quicker than prediction shown in Figure 92.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #11, January 22, 1991.

Wallace, J. M., AA3 Analyses for the Safety Rod SCRAM Tests During K-14 Startup Testing Program (U), RRD-RTS-910071, February 8, 1991.

Section 15: RSP 90-007-16 Control Rod Worth During Xenon Transient

This test will measure the differential control rod worths by following the xenon build-in and decay from a reactor shutdown. This test will require the reactor to be started up shortly after it has been shutdown to allow for measurements to be made while the xenon is changing. This test will provide more information on the worth of the control rods because larger axial distances will be covered by the control rods than during the tests performed at initial startup. The xenon reactivity worth can be assessed from the results of this test.

Predictions: Xenon decay curves for shutdowns from various equilibrium power levels are given in Figures 93 - 107.

Acceptance Criteria: The ECP requirements in DPSOL 105-1060A for shutdown recovery must be met.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #16, January 22, 1991.

Bond, R. A., Calculations for Control Rod Worth Measurements During K Reactor Startup and Power Ascension (U), WSRC-TR-91-42-044, June 1991.

Rosser, M. A., Mark 22 Initial Critical Rod Worth Curves (U), WSRC-TR-91-42-033, May 1991.

Swingle, R. F., At-Power and Recovery Startup Control Rod Worth Curves for The K-14-1 Subcycle (U), WSRC-TR-91-42-045, May 30, 1991.

Section 16: RSP 90-007-17 Safety Rod SCRAM with Distorted Axial Flux Shape

This test will verify safety rod worth when the neutron flux is peaked towards the bottom of the reactor (Roof Top Ratio (RTR) = 0.90). Safety analyses assume this is a worst case condition. With the flux peaked at the bottom of the reactor, the safety rods will not be fully effective until they are near the bottom of the reactor. This test will compare the observed relative change in flux with predictions taken from safety analyses.

Predictions: Expected decrease in relative flux caused by a safety rod SCRAM is shown in Figure 108.

Acceptance Criteria: The observed relative flux as measured by neutron flux detectors will decrease greater and quicker than prediction shown in Figure 108.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #17, November 7, 1990.

Wallace, J. M., AA3 Analyses for the Safety Rod SCRAM Tests During K-14 Startup Testing Program (U), RRD-RTS-910071, February 8, 1991.

Section 17: RSP 90-007-18 Reactor Shutdown by Supplementary Safety System (SSS)

This test will confirm that one side of the SSS is capable of shutting down the reactor. The observed reactor response as determined by the assembly effluent temperature-versus-time on the Data Acquisition System will be compared to predictions. Observed responses on the following instruments will also be compared to predictions:

Internal Fission Counter Rod (2 neutron detectors and 1 gamma detector) located in sector without sparger injection.

Predictions: Expected decrease in relative flux and assembly delta T caused by SSS injection are shown in Figures 109 and 110 respectively.

Acceptance Criteria: The observed relative flux as measured by neutron flux detectors, and observed change in assembly delta T will decrease greater and quicker than predictions shown in Figures 109 and 110.

Measured injection line pressure and poison solution levels in storage tank versus time following system actuation satisfy the parameter ranges shown in Table 7.

References: Restart Test Identification Report #4, K-Reactor Power Ascension (U), WSRC-TR-90-29-004K, Outline #18, February 27, 1991.

Byrne, B. A. and Paik, I. K., Supplementary Safety System and Safety Rod Startup Test Acceptance Criteria, SRL-SAG-910306, WSRC-RP-91-584, June 1991.

TABLE 1
REACTIVITY HELD IN FISSION PRODUCTS DURING POWER ASCENSION

Power Ascension - 1 Week at 60% Power

Power Level	Actual Power (MW)	Reactivity held in Fission Products (ΔK)		
		Min	Estimated	Max
<u>Full Power - 600 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	120	0.00548	0.00648	0.00748
40 %	240	0.01013	0.01126	0.01239
60 %	360	0.01411	0.01568	0.01725
90 %	540	0.01747	0.01941	0.02135
<u>Full Power - 700 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	140	0.00634	0.00734	0.00834
40 %	280	0.01124	0.01249	0.01374
60 %	420	0.01544	0.01716	0.01888
90 %	630	0.01886	0.02095	0.02304
<u>Full Power - 800 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	160	0.00716	0.00816	0.00916
40 %	320	0.01225	0.01361	0.01497
60 %	480	0.01663	0.01848	0.02033
90 %	720	0.02004	0.02227	0.02450
<u>Full Power - 900 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	180	0.00793	0.00893	0.00993
40 %	360	0.01317	0.01463	0.01609
60 %	540	0.01768	0.01965	0.02162
90 %	810	0.02108	0.02342	0.02576
<u>Full Power - 1000 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	200	0.00866	0.00966	0.01066
40 %	400	0.01401	0.01557	0.01713
60 %	600	0.01864	0.02071	0.02278
90 %	900	0.02200	0.02444	0.02688
<u>Full Power - 1100 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	220	0.00932	0.01035	0.01139
40 %	440	0.01478	0.01642	0.01806
60 %	660	0.01949	0.02166	0.02383
90 %	990	0.02281	0.02534	0.02787
<u>Full Power - 1200 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	240	0.00991	0.01101	0.01211
40 %	480	0.01549	0.01721	0.01893
60 %	720	0.02028	0.02253	0.02478
90 %	1080	0.02353	0.02614	0.02875

TABLE 2
REACTIVITY HELD IN FISSION PRODUCTS DURING POWER ASCENSION

Power Ascension - 3 Weeks at 60% Power

Power Level	Actual Power (MW)	Reactivity held in Fission Products (ΔK)		
		Min	Estimated	Max
<u>Full Power - 600 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	120	0.00548	0.00648	0.00748
40 %	240	0.01013	0.01126	0.01239
60 %	360	0.01575	0.01750	0.01925
90 %	540	0.01895	0.02106	0.02317
<u>Full Power - 700 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	140	0.00634	0.00734	0.00834
40 %	280	0.01124	0.01249	0.01374
60 %	420	0.01723	0.01914	0.02105
90 %	630	0.02043	0.02270	0.02497
<u>Full Power - 800 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	160	0.00716	0.00816	0.00916
40 %	320	0.01225	0.01361	0.01497
60 %	480	0.01852	0.02058	0.02264
90 %	720	0.02170	0.02411	0.02652
<u>Full Power - 900 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	180	0.00793	0.00893	0.00993
40 %	360	0.01317	0.01463	0.01609
60 %	540	0.01967	0.02186	0.02405
90 %	810	0.02278	0.02531	0.02784
<u>Full Power - 1000 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	200	0.00866	0.00966	0.01066
40 %	400	0.01401	0.01557	0.01713
60 %	600	0.02069	0.02299	0.02529
90 %	900	0.02372	0.02636	0.02900
<u>Full Power - 1100 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	220	0.00932	0.01035	0.01139
40 %	440	0.01478	0.01642	0.01806
60 %	660	0.02161	0.02401	0.02641
90 %	990	0.02454	0.02727	0.03000
<u>Full Power - 1200 MW</u>				
	75	0.00000	0.00019	0.00038
20 %	240	0.00991	0.01101	0.01211
40 %	480	0.01549	0.01721	0.01893
60 %	720	0.02243	0.02492	0.02741
90 %	1080	0.02527	0.02808	0.03089

TABLE 3
REACTIVITY HELD IN TEMPERATURE AND FISSION PRODUCTS

Power Ascension - 1 Week at 60% Power

Power Level	Actual Power (MW)	ΔK held in Min	Temperature and Estimated	Fission Products Max
<u>Full Power - 600 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	120	0.00563	0.00677	0.00792
40 %	240	0.01043	0.01185	0.01327
60 %	360	0.01455	0.01656	0.01857
90 %	540	0.01813	0.02073	0.02333
<u>Full Power - 700 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	140	0.00651	0.00768	0.00885
40 %	280	0.01158	0.01317	0.01476
60 %	420	0.01596	0.01819	0.02041
90 %	630	0.01963	0.02249	0.02535
<u>Full Power - 800 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	160	0.00736	0.00855	0.00975
40 %	320	0.01264	0.01439	0.01614
60 %	480	0.01722	0.01965	0.02209
90 %	720	0.02093	0.02403	0.02714
<u>Full Power - 900 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	180	0.00815	0.00937	0.01059
40 %	360	0.01361	0.01551	0.01741
60 %	540	0.01835	0.02097	0.02359
90 %	810	0.02207	0.02540	0.02873
<u>Full Power - 1000 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	200	0.00891	0.01015	0.01139
40 %	400	0.01450	0.01655	0.01859
60 %	600	0.01938	0.02218	0.02498
90 %	900	0.02310	0.02664	0.03018
<u>Full Power - 1100 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	220	0.00959	0.01089	0.01220
40 %	440	0.01532	0.01750	0.01967
60 %	660	0.02030	0.02327	0.02624
90 %	990	0.02402	0.02776	0.03150
<u>Full Power - 1200 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	240	0.01020	0.01160	0.01299
40 %	480	0.01608	0.01838	0.02069
60 %	720	0.02116	0.02429	0.02742
90 %	1080	0.02485	0.02878	0.03271

TABLE 4
REACTIVITY HELD IN TEMPERATURE AND FISSION PRODUCTS

Power Ascension - 3 Weeks at 60% Power

Power Level	Actual Power (MW)	ΔK held in Min	Temperature and Estimated	Fission Products Max
<u>Full Power - 600 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	120	0.00563	0.00677	0.00792
40 %	240	0.01043	0.01185	0.01327
60 %	360	0.01619	0.01838	0.02057
90 %	540	0.01962	0.02238	0.02514
<u>Full Power - 700 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	140	0.00651	0.00768	0.00885
40 %	280	0.01158	0.01317	0.01476
60 %	420	0.01774	0.02017	0.02259
90 %	630	0.02120	0.02424	0.02728
<u>Full Power - 800 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	160	0.00736	0.00855	0.00975
40 %	320	0.01264	0.01439	0.01614
60 %	480	0.01911	0.02175	0.02440
90 %	720	0.02258	0.02587	0.02916
<u>Full Power - 900 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	180	0.00815	0.00937	0.01059
40 %	360	0.01361	0.01551	0.01741
60 %	540	0.02034	0.02318	0.02602
90 %	810	0.02377	0.02729	0.03081
<u>Full Power - 1000 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	200	0.00891	0.01015	0.01139
40 %	400	0.01450	0.01655	0.01859
60 %	600	0.02143	0.02446	0.02749
90 %	900	0.02483	0.02856	0.03229
<u>Full Power - 1100 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	220	0.00959	0.01089	0.01220
40 %	440	0.01532	0.01750	0.01967
60 %	660	0.02242	0.02562	0.02883
90 %	990	0.02576	0.02969	0.03362
<u>Full Power - 1200 MW</u>				
	75	0.00009	0.00037	0.00065
20 %	240	0.01020	0.01160	0.01299
40 %	480	0.01608	0.01838	0.02069
60 %	720	0.02331	0.02668	0.03005
90 %	1080	0.02660	0.03072	0.03485

TABLE 5
Relative Radial Power Shape Limits
Double Partial Rods at 800 vu

Full Rod Position	Limits	Gang 1	Gang 2	Gang 3	Buckled Zone
2500 vu	Lower Upper	1.100 0.900	1.019 0.833	0.887 0.591	0.715 0.477
2400 vu	Lower Upper	1.100 0.900	1.016 0.832	0.883 0.589	0.709 0.473
2300 vu	Lower Upper	1.100 0.900	1.015 0.831	0.880 0.586	0.706 0.470
2200 vu	Lower Upper	1.100 0.900	1.011 0.827	0.872 0.582	0.694 0.462
2100 vu	Lower Upper	1.100 0.900	1.007 0.824	0.864 0.576	0.680 0.454
2000 vu	Lower Upper	1.100 0.900	1.007 0.824	0.863 0.575	0.679 0.453
1900 vu	Lower Upper	1.100 0.900	1.007 0.824	0.863 0.575	0.679 0.453
1800 vu	Lower Upper	1.100 0.900	1.003 0.821	0.858 0.572	0.671 0.447
1700 vu	Lower Upper	1.100 0.900	1.000 0.818	0.851 0.567	0.660 0.440
1600 vu	Lower Upper	1.100 0.900	0.998 0.816	0.847 0.565	0.653 0.435
1500 vu	Lower Upper	1.100 0.900	0.997 0.815	0.845 0.563	0.649 0.433
1400 vu	Lower Upper	1.100 0.900	0.996 0.815	0.842 0.561	0.647 0.431
1300 vu	Lower Upper	1.100 0.900	0.994 0.814	0.840 0.560	0.643 0.429

TABLE 6
Limits on Axial Power Shape
Double Partial Rods at 800 vu

Full Rod Position	Limit	Sensor 1 (top)	Sensor 2	Sensor 3	Sensor 4	Sensor 5	Sensor 6	Sensor 7 (bottom)
2500 vu	Lower	0.119	0.368	0.464	0.830	1.065	1.032	0.673
	Upper	0.819	1.068	1.164	1.530	1.765	1.732	1.373
2400 vu	Lower	0.141	0.415	0.533	0.917	1.005	0.945	0.593
	Upper	0.841	1.115	1.233	1.617	1.705	1.645	1.293
2300 vu	Lower	0.205	0.527	0.675	0.918	0.903	0.827	0.495
	Upper	0.905	1.227	1.375	1.618	1.603	1.527	1.195
2200 vu	Lower	0.412	0.822	0.844	0.839	0.698	0.610	0.325
	Upper	1.112	1.522	1.544	1.539	1.398	1.310	1.025
2100 vu	Lower	0.668	0.989	0.922	0.758	0.549	0.456	0.207
	Upper	1.368	1.689	1.622	1.458	1.249	1.156	0.907
2000 vu	Lower	0.693	1.004	0.929	0.750	0.535	0.442	0.197
	Upper	1.393	1.704	1.629	1.450	1.235	1.142	0.897
1900 vu	Lower	0.689	0.999	0.924	0.749	0.538	0.447	0.204
	Upper	1.389	1.699	1.624	1.449	1.238	1.147	0.904
1800 vu	Lower	0.566	0.852	0.800	0.709	0.622	0.591	0.409
	Upper	1.266	1.552	1.500	1.409	1.322	1.291	1.109
1700 vu	Lower	0.378	0.625	0.609	0.653	0.782	0.857	0.646
	Upper	1.078	1.325	1.309	1.353	1.482	1.557	1.346
1600 vu	Lower	0.290	0.522	0.527	0.654	0.901	0.950	0.705
	Upper	0.990	1.222	1.227	1.354	1.601	1.650	1.405
1500 vu	Lower	0.262	0.496	0.516	0.720	0.923	0.947	0.687
	Upper	0.962	1.196	1.216	1.420	1.623	1.647	1.387
1400 vu	Lower	0.280	0.531	0.566	0.781	0.882	0.885	0.625
	Upper	0.980	1.231	1.266	1.481	1.582	1.585	1.325
1300 vu	Lower	0.341	0.628	0.679	0.783	0.799	0.784	0.536
	Upper	1.041	1.328	1.379	1.483	1.499	1.484	1.236

TABLE 7

SSS INJECTION TIMING AND FLOW CHARACTERISTICS

PARAMETERS TO BE MEASURED

RESPONSE TIMES

Sparger Injection

Time delay from explosive valve circuit switch contact to doughnut flange indication of poison solution injection (latest of 3 lines)

Pump Suction Injection

Time delay from explosive valve switch contact to rupture disk indication of onset of injection into process water system (latest of 3 injection peaks)

INJECTION FLOW CURVES

Sparger Injection

Cumulative volume of poison solution, as indicated by decreasing level in storage tank

Pump Suction Injection

Cumulative volume of poison solution, as indicated by decreasing level in storage tank

PARAMETER VALUES, RANGES TO BE OBTAINED

≤ 0.37 seconds

Ensures poison solution effect on reactivity within 0.7 seconds and poison solution delivery to moderator space within 1.0 second, as specified in SAR Chapter 15 accident analysis

≤ 3.3 seconds

Ensures poison solution delivery into PWS within 4.0 seconds assumed in SAR Chapter 15 accident analysis

Time(sec)	Cumulative Volume Injected Gallons	
	Lower	Upper
5.0	7.0	8.5
10.0	12.0	15.5
15.0	16.0	21.0
20.0	20.0	26.0
25.0	23.5	30.5
30.0	27.0	34.5
35.0	29.5	38.5

Time(sec)	Cumulative Volume Injected Gallons	
	Lower	Upper
5.0	4.0	7.0
10.0	7.0	13.0
15.0	10.0	17.0
20.0	13.0	21.0
25.0	15.0	25.0
30.0	17.0	28.0
35.0	19.0	32.0
40.0	21.0	35.0
45.0	22.0	38.0
50.0	24.0	41.0
55.0	26.0	43.0

INJECTION DURATION

Sparger Injection

≥ 35.0 seconds

Indicated by time difference between latest of injection line pressure peaks and earliest of injection line indications of loss of flow past doughnut flange

Pump Suction Injection

≥ 70.0 seconds

Time between rupture disk indication (latest of 3 injection line pressure peaks) and end of injection (earliest of injection line pressure indications of loss of flow)

FIGURE 1

K-effective VS FULL ROD POSITION

DOUBLE PARTIAL RODS AT 800 VU

FIGURE 2

K-effective VS FULL ROD POSITION WEAK PARTIAL RODS AT 800 VU

FIGURE 3

K-effective VS FULL ROD POSITION DOUBLE PARTIAL RODS AT 700 VU

FIGURE 4

K-effective VS FULL ROD POSITION

WEAK PARTIAL RODS AT 700 VU

FIGURE 5

K-effective VS FULL ROD POSITION DOUBLE PARTIAL RODS AT 950 VU

FIGURE 6

K-effective VS FULL ROD POSITION

WEAK PARTIAL RODS AT 950 VU

FIGURE 7

Full Control Rod Withdrawal - 50 vu

Double Partial Control Rods at 800 vu

FIGURE 8

Full Control Rod Withdrawal - 50 vu

Weak Partial Control Rods at 800 vu

FIGURE 9

Full Control Rod Withdrawal - 50 vu

Double Partial Rods at 700 vu

FIGURE 10

Full Control Rod Withdrawal - 50 vu

Weak Partial Control Rods at 700 vu

FIGURE 11

Full Control Rod Withdrawal - 50 vu

Double Partial Control Rods at 950 vu

FIGURE 12

Full Control Rod Withdrawal - 50 vu

Weak Partial Control Rods at 950 vu

FIGURE 13

Full Rod Withdrawal - 10 PCM Reactivity Double Partial Rods at 800 vu

FIGURE 14

Full Rod Withdrawal - 10 PCM Reactivity Double Partial Rods at 800 vu

FIGURE 15

Full Rod Withdrawal - 20 PCM Reactivity Double Partial Rods at 800 vu

FIGURE 16

Full Rod Withdrawal - 20 PCM Reactivity Double Partial Rods at 800 vu

FIGURE 17

Full Rod Withdrawal - 30 PCM Reactivity Double Partial Rods at 800 vu

FIGURE 18

Full Rod Withdrawal - 30 PCM Reactivity Double Partial Rods at 800 vu

FIGURE 19

Full Rod Withdrawal - 10 PCM Reactivity Double Partial Rods at 700 vu

FIGURE 20

Full Rod Withdrawal - 10 PCM Reactivity Double Partial Rods at 700 vu

FIGURE 21

Full Rod Withdrawal - 10 PCM Reactivity Double Partial Rods at 700 vu

FIGURE 22

Full Rod Withdrawal - 20 PCM Reactivity Double Partial Rods at 700 vu

FIGURE 23

Full Rod Withdrawal - 20 PCM Reactivity

Double Partial Rods at 700 vu

FIGURE 24

Full Rod Withdrawal - 20 PCM Reactivity Double Partial Rods at 700 vu

FIGURE 25

Full Rod Withdrawal - 30 PCM Reactivity

Double Partial Rods at 700 vu

FIGURE 26

Full Rod Withdrawal - 30 PCM Reactivity Double Partial Rods at 700 vu

FIGURE 27

Full Rod Withdrawal - 30 PCM Reactivity

Double Partial Rods at 700 vu

FIGURE 28

Full Rod Withdrawal - 10 PCM Reactivity Double Partial Rods at 950 vu

FIGURE 29

Full Rod Withdrawal - 10 PCM Reactivity Double Partial Rods at 950 vu

FIGURE 30

Full Rod Withdrawal - 20 PCM Reactivity Double Partial Rods at 950 vu

FIGURE 31

Full Rod Withdrawal - 20 PCM Reactivity Double Partial Rods at 950 vu

FIGURE 32

Full Rod Withdrawal - 30 PCM Reactivity Double Partial Rods at 950 vu

FIGURE 33

Full Rod Withdrawal - 30 PCM Reactivity

Double Partial Rods at 950 vu

FIGURE 34

Full Rod Withdrawal - 10 PCM Reactivity Weak Partial Rods at 800 vu

FIGURE 35

Full Rod Withdrawal - 10 PCM Reactivity Weak Partial Rods at 800 vu

FIGURE 36

Full Rod Withdrawal - 20 PCM Reactivity Weak Partial Rods at 800 vu

FIGURE 37

Full Rod Withdrawal - 20 PCM Reactivity Weak Partial Rods at 800 vu

FIGURE 38

Full Rod Withdrawal - 30 PCM Reactivity Weak Partial Rods at 800 vu

FIGURE 39

Full Rod Withdrawal - 30 PCM Reactivity

Weak Partial Rods at 800 vu

FIGURE 40

Full Rod Withdrawal - 10 PCM Reactivity Weak Partial Rods at 700 vu

FIGURE 41

Full Rod Withdrawal - 10 PCM Reactivity Weak Partial Rods at 700 vu

FIGURE 42

Full Rod Withdrawal - 20 PCM Reactivity Weak Partial Rods at 700 vu

FIGURE 43

Full Rod Withdrawal - 20 PCM Reactivity Weak Partial Rods at 700 vu

FIGURE 44

Full Rod Withdrawal - 30 PCM Reactivity Weak Partial Rods at 700 vu

FIGURE 45

Full Rod Withdrawal - 30 PCM Reactivity

Weak Partial Rods at 700 vu

FIGURE 46

Full Rod Withdrawal - 10 PCM Reactivity Weak Partial Rods at 950 vu

FIGURE 47

Full Rod Withdrawal - 10 PCM Reactivity Weak Partial Rods at 950 vu

FIGURE 48

Full Rod Withdrawal - 20 PCM Reactivity Weak Partial Rods at 950 vu

FIGURE 49

Full Rod Withdrawal - 20 PCM Reactivity

Weak Partial Rods at 950 vu

FIGURE 50

Full Rod Withdrawal - 30 PCM Reactivity

Weak Partial Rods at 950 vu

FIGURE 51

Full Rod Withdrawal - 30 PCM Reactivity

Weak Partial Rods at 950 vu

FIGURE 52

REACTIVITY WORTH - CLUSTER 1 STRONG PARTIAL ROD 800 VU TO 1000 VU

FIGURE 53

REACTIVITY WORTH - CLUSTER 36 STRONG PARTIAL ROD 800 VU TO 1000 VU

FIGURE 54

REACTIVITY WORTH - CLUSTER 52 STRONG PARTIAL ROD 800 VU TO 1000 VI

FIGURE 55

REACTIVITY WORTH - CLUSTER 1 WEAK PARTIAL ROD 800 VU TO 1000 VU

FIGURE 56

REACTIVITY WORTH - CLUSTER 36 WEAK PARTIAL ROD 800 VU TO 1000 VU

FIGURE 57

REACTIVITY WORTH - CLUSTER 52 WEAK PARTIAL ROD 800 VU TO 1000 VU

FIGURE 58

Reactivity Held in Temperature For Zero Reactor Exposure (0 - 800 MW)

FIGURE 59

Reactivity Held in Temperature For Zero Reactor Exposure (800 - 1600 MW)

FIGURE 61

Cluster 20 Strong Li Integral Rod Insertion at 60% Power

FIGURE 60

Cluster 3 Strong Li Integral Rod Insertion at 60% Power

FIGURE 62

Cluster 54 Strong Li Integral Rod Insertion at 60% Power

FIGURE 63

Cluster 54 Strong Li Integral Rod Insertion at 60% Power

FIGURE 64

Cluster 54 Strong Li Integral Rod Insertion at 60% Power

FIGURE 65

Cluster 1 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 66

Cluster 1 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 67

Cluster 1 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 68

Cluster 36 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 69

Cluster 36 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 70

Cluster 36 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 71

Cluster 52 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 72

Cluster 52 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 73

Cluster 52 Strong Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 74

Cluster 1 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 75

Cluster 1 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 76

Cluster 1 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 77

Cluster 36 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 78

Cluster 36 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 79

Cluster 36 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 80

Cluster 52 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 81

Cluster 52 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 82

Cluster 52 Weak Partial Rod Insertion 800 vu to 1000 vu at 60% Power

FIGURE 83

Gang 1 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 84

Gang 1 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 85

Gang 1 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 86

Gang 2 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 87

Gang 2 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 88

Gang 2 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 89

Gang 3 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 90

Gang 3 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 91

Gang 3 Partial Rod Insertion 800 vu to 850 vu at 60% Power

FIGURE 92

Safety Rod SCRAM

Flat Core and No Rods Missing

FIGURE 93

Reactivity Worth of Fission Products After Shutdown From 400 MW Equilibrium

FIGURE 94

Reactivity Worth of Fission Products After Shutdown From 450 MW Equilibrium

FIGURE 95

Reactivity Worth of Fission Products After Shutdown From 500 MW Equilibrium

FIGURE 96

Reactivity Worth of Fission Products After Shutdown From 550 MW Equilibrium

FIGURE 97

Reactivity Worth of Fission Products After Shutdown From 600 MW Equilibrium

FIGURE 98

Reactivity Worth of Fission Products After Shutdown From 650 MW Equilibrium

FIGURE 99

Reactivity Worth of Fission Products After Shutdown From 700 MW Equilibrium

FIGURE 100

Reactivity Worth of Fission Products After Shutdown From 750 MW Equilibrium

FIGURE 101

Reactivity Worth of Fission Products After Shutdown From 800 MW Equilibrium

FIGURE 102

Reactivity Worth of Fission Products After Shutdown From 850 MW Equilibrium

FIGURE 103

Reactivity Worth of Fission Products After Shutdown From 900 MW Equilibrium

FIGURE 104

Reactivity Worth of Fission Products After Shutdown From 950 MW Equilibrium

FIGURE 105

Reactivity Worth of Fission Products After Shutdown From 1000 MW Equilibrium

FIGURE 106

Reactivity Worth of Fission Products After Shutdown From 1050 MW Equilibrium

FIGURE 107

Reactivity Worth of Fission Products After Shutdown From 1100 MW Equilibrium

FIGURE 108

Safety Rod SCRAM

Tilted Core and No Rods Missing

FIGURE 109

SSS Acceptance Criteria For Relative Flux

FIGURE 110

SSS Acceptance Criteria For Relative Assembly Delta T

END

**DATE
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8 / 31 / 92