The data was found to be poolable between these subsets which indicates that different modern PWR methods provide CEA bank worth predictions with similar accuracy.

B.3.2 Review of CEA Total Worth Data

Tables B-4, B-5, and B-6 provide the CEA total worth data for DIT/ROCS, PHOENIX/ANC, and CASMO/(SIMULATE or XGT or PRISM) respectively. The CEA total worth is the worth of all CEA groups measured.

Figure B-3 provides a plot of CEA total worth data for DIT/ROCS along with the uncertainty derived from previous benchmarking. Figure B-4 provides a plot of recent CEA total worth data for DIT/ROCS, PHOENIX/ANC, and CASMO/(SIMULATE or XGT or PRISM) along with the 95/95 tolerance derived from the combined data.

B.3.2.1 CEA Total Worth Data Distribution

A normality test was performed on the data in Figures B-3 and B-4 that confirmed the CEA total worth data is consistent with a normal distribution. This included the individual subsets of data for each method in Figure B-4 as well as the combined data. The mean value of the recent DIT/ROCS data in Figure B-3 is [ ] which is small compared to the DIT/ROCS uncertainty of [ ] derived from previous benchmarking indicating a significant bias is not present. The CEA total worth data distribution indicates [

]

B.3.2.2 CEA Total Worth Data Variability

All of the recent DIT/ROCS data in Figure B-3 is less than the uncertainty indicating consistency with previous benchmarking. The variability of the recent CEA total worth data thus [

] In addition, the 95/95 tolerance derived from the combined DIT/ROCS, PHOENIX/ANC, and CASMO/(SIMULATE or XGT or PRISM) data in Figure B-4 is [ ] which is consistent with the DIT/ROCS uncertainty of [ ] derived from previous benchmarking. Thus, the variability of the data for different core design methods indicates that [

]

B.3.2.3 CEA Total Worth Data Poolability between Methods

A poolability test was performed on the following subsets of CEA total worth data in Figure B-4 that represent different modern core design methods:

- DIT/ROCS
- PHOENIX/ANC
- CASMO/(SIMULATE or XGT or PRISM)

[

]

B.3.3 Review of Isothermal Temperature Coefficient (ITC) Data

Tables B-7, B-8, and B-9 provide the ITC data for DIT/ROCS, PHOENIX/ANC, and CASMO/(SIMULATE or XGT or PRISM) respectively. The DIT/ROCS data includes data from previous benchmarking along with recent data. The DIT/ROCS data also contains BOC HZP and HFP data along with some MOC HFP and EOC HZP data.

Figure B-5 provides a plot of ITC data for DIT/ROCS along with the uncertainty derived from previous benchmarking. Figure B-6 provides a plot of recent ITC data for DIT/ROCS, PHOENIX/ANC, and CASMO/(SIMULATE or XGT or PRISM) along with the 95/95 tolerance derived from the combined data.

B.3.3.1 ITC Data Distribution

A normality test was performed on the data in Figures B-5 and B-6 that confirmed the ITC data is consistent with a normal distribution. This included the individual subsets of data for each operating condition in Figure B-5 and each method in Figure B-6 as well as the combined data. The mean value of the recent DIT/ROCS data in Figure B-5 is [ ] which is small compared to the DIT/ROCS uncertainty of [ ] derived from previous benchmarking indicating a significant bias is not present. The ITC data distribution indicates [ ]

B.3.3.2 ITC Data Variability

The preponderance of recent DIT/ROCS data in Figure B-5 is less than the uncertainty indicating consistency with previous benchmarking. The variability of the recent ITC data thus verifies [ ] In addition, the 95/95 tolerance derived from the combined DIT/ROCS, PHOENIX/ANC, and CASMO/(SIMULATE or XGT or PRISM) data in Figure B-6 is [ ] which is consistent with the DIT/ROCS uncertainty of [ ] derived from previous benchmarking. Thus, the variability of the data for different core design methods indicates that [ ]

B.3.3.3 ITC Data Poolability between Methods

A poolability test was performed on the following subsets of ITC data in Figure B-6 that represent different modern core design methods:

- DIT/ROCS
- PHOENIX/ANC
- CASMO/(SIMULATE or XGT or PRISM)

[ ]

B.3.3.4 ITC Data Poolability between Operating Conditions

A poolability test was performed on the following subsets of DIT/ROCS ITC data in Figure B-5 that represent different operating conditions:

- [

]

[

] The STAR Program eliminates the BOC HZP ITC measurement and supports the continued elimination of the MOC at power ITC measurement to verify EOC MTC Technical Specification compliance for plants that have already eliminated this measurement in accordance Reference B-2. For these plants it is acceptable to rely on the BOC MTC Surveillance test at power to determine if the criteria for eliminating the MOC MTC Surveillance test is satisfied.

B.4 CONCLUSIONS

B.4.1 Startup Test Data Distribution

It is concluded from the review of the distribution of the startup test data that [

] This conclusion supports the reliance on CEA worth and ITC predictions instead of measurements at HZP in the STAR Program.

B.4.2 Startup Test Data Variability

It is concluded from the review of the variability of the startup test data that the deviations verify the continued applicability of the uncertainties established for CEA worth and ITC by previous benchmarking. It is further concluded that the deviations justify the elimination of all tests of CEA worth and ITC to verify accuracy after benchmarking provided the Core Design Applicability Requirements in Table 3-4 are satisfied. These conclusions are summarized in Table B-10 and are used in justifying the elimination of the CEA Worth test at HZP.

B.4.3 Startup Test Data Poolability

It is concluded from the review of the poolability of the startup test data between DIT/ROCS, PHOENIX/ANC, and CASMO/(SIMULATE or XGT or PRISM) that [

] This conclusion supports the applicability of STAR to all PWRs using modern physics methods. It is also concluded from the review of the poolability of the ITC startup test data between different operating conditions that [

] This conclusion is summarized in Table B-10 and is used in justifying the elimination of the ITC measurement at HZP. In addition, it is concluded that for plants that have eliminated the MOC MTC Surveillance test contingent on the results of the BOC MTC Surveillance tests at HZP and power in accordance with Reference B-2, reliance on the MTC Surveillance test at power to make this determination is acceptable.

B.5 REFERENCES

B-1 American National Standard: Assessment of the Assumption of Normality. ANSI N15.15 (1974).

B-2 Amendment 1 to CE NPSD-911-P-A, "Analysis of Moderator Temperature Coefficients in support of a Change in the Technical Specification End of Cycle Negative MTC Limit," January 1998.

Table B-1 DIT/ROCS Startup Test Data for CEA Bank Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-1 DIT/ROCS Startup Test Data for CEA Bank Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-1 DIT/ROCS Startup Test Data for CEA Bank Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-2 PHOENIX/ ANC Startup Test Data for CEA Bank Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-2 PHOENIX/ ANC Startup Test Data for CEA Bank Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-2 PHOENIX/ ANC Startup Test Data for CEA Bank Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-2 PHOENIX/ ANC Startup Test Data for CEA Bank Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-2 PHOENIX/ ANC Startup Test Data for CEA Bank Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-3 CASMO Startup Test Data for CEA Bank Worth Deviations

(CASMO DATA IS CASMO/SIMULATE UNLESS OTHERWISE NOTED)

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-3 CASMO Startup Test Data for CEA Bank Worth Deviations

(CASMO DATA IS CASMO/SIMULATE UNLESS OTHERWISE NOTED)

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-3 CASMO Startup Test Data for CEA Bank Worth Deviations

(CASMO DATA IS CASMO/SIMULATE UNLESS OTHERWISE NOTED)

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-3 CASMO Startup Test Data for CEA Bank Worth Deviations

(CASMO DATA IS CASMO/SIMULATE UNLESS OTHERWISE NOTED)

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-3 CASMO Startup Test Data for CEA Bank Worth Deviations

(CASMO DATA IS CASMO/SIMULATE UNLESS OTHERWISE NOTED)

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-3 CASMO Startup Test Data for CEA Bank Worth Deviations

(CASMO DATA IS CASMO/SIMULATE UNLESS OTHERWISE NOTED)

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-3 CASMO Startup Test Data for CEA Bank Worth Deviations

(CASMO DATA IS CASMO/SIMULATE UNLESS OTHERWISE NOTED)

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-4 DIT/ROCS Startup Test Data for CEA Total Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-5 PHOENIX/ANC Startup Test Data for CEA Total Worth Deviations

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-6 CASMO Startup Test Data for CEA Total Worth Deviations
(CASMO Data is CASMO/SIMULATE unless otherwise noted)
Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-6 CASMO Startup Test Data for CEA Total Worth Deviations
(CASMO Data is CASMO/SIMULATE unless otherwise noted)

Deviation = 100x(Measured - BE Predicted)/(BE Predicted)

Table B-7 DIT/ROCS Startup Test Data for ITC Deviations

Deviation = Measured - BE Predicted

Table B-7 DIT/ROCS Startup Test Data for ITC Deviations

Deviation = Measured - BE Predicted

Table B-7 DIT/ROCS Startup Test Data for ITC Deviations

Deviation = Measured - BE Predicted

Table B-7 DIT/ROCS Startup Test Data for ITC Deviations

Deviation = Measured - BE Predicted

Table B-7 DIT/ROCS Startup Test Data for ITC Deviations

Deviation = Measured - BE Predicted

Table B-8 PHOENIX/ANC Startup Test Data for ITC Deviations

Deviation = Measured - BE Prediction

Table B-8 PHOENIX/ANC Startup Test Data for ITC Deviations

Deviation = Measured - BE Prediction

Table B-8 PHOENIX/ANC Startup Test Data for ITC Deviations

Deviation = Measured - BE Prediction

Table B-9 CASMO Startup Test Data for ITC Deviations

(CASMO Data is CASMO/SIMULATE unless otherwise noted)

Deviation = Measured - BE Predicted

Table B-9 CASMO Startup Test Data for ITC Deviations

(CASMO Data is CASMO/SIMULATE unless otherwise noted)

Deviation = Measured - BE Predicted

Table B-10 Results from Analyses of Startup Test Data

[1] This data includes a range of modern PWR core design methods including DIT/ROCS, PHOENIX/ANC, and CASMO/SIMULATE. Included are measurements results for CEA worth and ITC from multiple cycles for Participating Plants as well as some nonparticipating CE Plants

FIGURE B-1 CEA Bank Worth Deviations vs Measured CEA Worth for DIT/ROCS Data

FIGURE B-2 CEA Bank Worth Deviations vs Measured CEA Worth for Recent Data

FIGURE B-3 CEA Total Worth Deviations vs Measured CEA Worth for DIT/ROCS Data

FIGURE B-4 CEA Total Worth Deviations vs Measured CEA Worth for using Recent Data

FIGURE B-5 ITC Deviations vs Measured CBC for DIT/ROCS Data

FIGURE B-6 ITC Deviations vs Measured CBC for Recent Data

APPENDIX C

AS-BUILT CORE PROBLEM DETECTION

C.1 INTRODUCTION

C.1.1 BACKGROUND

This appendix describes the development of matrices that provide the effectiveness of various methods of detecting as-built core problems by startup tests, pre-operational activities, and STAR Applicability Requirements. These matrices use a three level rating system to represent the effectiveness of the various methods in detecting as-built core problems. Detection methods are rated as "Good," "Fair," or "Poor." These effectiveness ratings are determined using engineering judgment. This information is used in the as-built core problem evaluations in Section 4.2 of this report to determine changes in the ability to detect problems between the Generic and STAR Programs. The information is also used in the evaluation of deviations from the Generic Program by Participating Plants in Appendix F.

C.1.2 PURPOSE

The purpose of this appendix is to determine the effectiveness of startup tests, pre-operational activities, and STAR Applicability Requirements in detecting as-built core problems.

C.2 DISCUSSION

Table C-1 presents a problem detection matrix based on information in the ANSI standard for startup tests, Reference C-1. This matrix addresses the likelihood of a particular problem causing an unexpected result in a given test. The likelihood of actually detecting the problem may be somewhat different from the likelihood in Table C-1 because the effect on the test result may not be sufficient to result in detection. More detailed discussions concerning the likelihood of detecting specific problems are provided in the evaluations of each problem in Appendix E.

Table C-2 provides an expanded problem detection matrix that includes the full set of tests[21] and problems[22] addressed in the evaluations. This matrix addresses the likelihood of a particular problem being detected by a given test. Both tests and problems that were not within the scope of the ANSI standard are addressed in the evaluations. Also, the descriptions of problems have been changed from those in the ANSI standard to provide more comprehensive categories of problems. The likelihood of detecting an as-built problem is based on engineering judgment by individuals experienced in safety analysis, startup testing, and plant operation. These judgments are based on credible problems with the following considerations:

- The types of problems most likely to occur
- The typical method of performing tests
- The typical test criteria used

[21] Table 1-1 provides descriptions, and Table 1-2 provides the purposes, of the tests discussed in this report.
[22] Definitions and discussions of these problems are provided in the evaluations of each problem in Section 4.2.

Table C-3 provides the relationship between tests in the problem detection matrix from the ANSI standard in Table C-1, and the expanded problem detection matrix in Table C-2. The expanded problem detection matrix in Table C-2 contains the following additional tests that are not part of the ANSI set of tests in Table C-1:

- CEA Drop Time
- CEA Drop Characteristics
- CEA Flux Change
- MTC Surveillance
- MTC Alternate Surveillance
- SDM Surveillance

These tests are added because they can affect the detection of problems during startup testing. The CEA Drop Time, CEA Drop Characteristics, and CEA Flux Change tests are not included in the ANSI standard because the scope of the standard does not include mechanical tests of system components. The MTC Surveillance and SDM Surveillance are not included in the ANSI standard because the scope of the standard does not include surveillance of reactor physics parameters[23]. The MTC Alternate Surveillance test is a new test developed as part of the STAR Program.

In addition, the Flux Symmetry test from the ANSI standard is listed as the following two separate tests, each corresponding to one of the methods for performing the Flux Symmetry test discussed in the ANSI standard:

- CEA Flux Symmetry
- Incore Flux Symmetry

The reason for considering the two methods from the ANSI standard as separate tests is that they differ on their ability to detect CEA related problems. This is because one method involves measuring CEA worth, and the other method is typically performed near ARO. Tests performed near ARO have a low likelihood of detecting CEA related problems provided the CEAs are coupled.

Table C-4 provides the relationship between problems in the problem detection matrix from the ANSI standard in Table C-1, and the expanded problem detection matrix in Table C-2. The expanded problem detection matrix in Table C-2 contains the following additional problems that are not part of the ANSI set of problems in Table C-1:

- MTC Noncompliance
- SDM Noncompliance

These problems address potential noncompliance with Technical Specification limits, which are not included in the ANSI standard because the scope of the standard does not include surveillance of reactor physics parameters.

The expanded problem detection matrix in Table C-2 also differs from the ANSI problem detection matrix in Table C-1 in how the ability to detect problems is presented. The ANSI problem detection matrix uses a two level rating system representing the likelihood of a problem causing an unexpected result for the test. Problems are rated as "will most likely" or "may" cause an unexpected result. The expanded problem detection matrix developed for this evaluation uses a three level rating system to represent the effectiveness of a test in detecting a problem. Tests are rated as "Good," "Fair," or "Poor" in effectiveness in detecting the problem. A three level rating system was used because of the wide variations in the ability to detect problems.

[23] The scope of the ANSI standard is presented in Section 2 of Reference F-1.

Table C-5 presents a problem detection matrix for startup tests that is based on the expanded problem detection matrix in Table C-2. In order to evaluate the impact of the test changes on the Generic Program, all the tests involved in both the Generic and STAR Programs need to be considered. This problem detection matrix addresses all the tests in both the Generic and STAR Programs. Changes from the Generic to STAR Program are also identified. This problem detection matrix for startup tests provides information for the following subset of tests involved in both the Generic and STAR Programs described in Section 3.0 of this report:

- CEA Drop Time while shutdown
- CEA Drop Characteristics while shutdown
- CBC at HZP
- CEA Worth at HZP
- ITC at HZP
- MTC Surveillance at HZP
- MTC Alternate Surveillance at HZP
- Incore Flux Symmetry at low power
- Incore Power Distribution at intermediate power
- ITC at intermediate to HFP
- MTC Surveillance at intermediate to HFP
- Incore Power Distribution at HFP
- ΔCBC HZP-HFP at HFP

Table C-6 presents a problem detection matrix for pre-operational activities. The following pre-operational activities have some ability to detect problems and are rated in Table C-6 using the same three level rating system used in the problem detection matrix for startup tests:

- Core Design QA
- Fuel Fabrication QA
- CEA Fabrication QA
- EOC CEA insertion
- CEA manipulation
- Fuel manipulation
- Core verification
- CEA coupling verification
- CEA position indication

Table C-7 presents a problem detection matrix for the STAR Applicability Requirements. The following STAR Applicability Requirements from Table 3-4 have some ability to detect problems and are rated in Table C-7 using the same three level rating system used in the problem detection matrix for startup tests:

- Core Design
- Fabrication
- Refueling
- Startup Testing
- CEA Lifetime

It is noted that some of the of the STAR Applicability Requirements from Table 3-4 require activities such as [ ] This is because they are considered important elements in the STAR Program although it is recognized that they are already performed in a typical refueling.

C.3 REFERENCES

C-1 ANSI/ANS-19.6.1-1997, "American National Standard Reload Startup Physics Tests for Pressurized Water Reactors," August 22, 1997

Table C-1 ANSI[1] Problem Detection Matrix

(1 = This problem will most likely cause an unexpected result for the test 2 = This problem may cause an unexpected result for the test)

TEST[2]	POWER	PROBLEM										
		Core Misloading	Loss of Rod Worth	Fuel (Assembly Bowing/Damage)	Boron (B10) Content	Analytical Errors	Flow/Temperature Anomalies	Burnable Poison Loss	Mechanical Failure / Misloading of Control Rod	Enrichment Error	Excessive Fuel Crudding	Measurement Process Failure
Critical Boron	HZP	2			1	1		2	2	2		
Differential Boron Worth	HZP		2		1	1			2			1
Rod Worth	HZP	2	1	2		1		2	1	2	2	2
ITC	HZP				2	2				2		2
Flux Symmetry (Method 1 or 2)	HZP or Low Power	1	2	2			2	2	1		2	
Power Distribution	Intermediate and HFP	1		2		1	1	1	1	1	2	
HZP to HFP Reactivity Difference	HFP				1	1		2	2	2	2	

[1] ANSI refers to the 1997 ANSI standard for reload startup physics tests, Reference 2, which is the source of the information for this matrix.

[2] Table 1-1 provides descriptions, and Table 1-2 provides the purposes, of the tests discussed in this report.

Table C-2 Expanded Problem Detection matrix

(Effectiveness of test in detecting problem: 1=Good 2=Fair 3=Poor)

[1] Table 1-1 provides descriptions, and Table 1-2 provides the purposes, of the tests discussed in this report.
[2] Definitions and discussions of these problems are provided in the report sections indicated by the number before the problem title.

Table C-3 Relationship between Tests in the ANSI and Expanded Problem Detection Matrices

EXPANDED MATRIX TEST[1]	POWER	RODS	ANSI MATRIX[2] TEST
CEA Drop Time	Shutdown	Moved	Outside scope
CEA Drop Characteristics	Shutdown	Moved	Outside scope
CEA Flux Change	HZP	Moved	Outside scope
CBC	HZP	ARO or Rodded	Critical Boron
IBW	HZP	Rodded	Differential Boron Worth
CEA Worth	HZP	Rodded	Rod Worth
ITC	HZP	ARO or Rodded	ITC
MTC Surveillance	HZP	ARO	Outside scope
MTC Alternate Surveillance	HZP	ARO	Outside scope
SDM Surveillance	HZP	ARO	Outside scope
CEA Flux Symmetry	HZP	Moved	Flux Symmetry (Method 2)
Incore Flux Symmetry	Low	ARO	Flux Symmetry (Method 1)
Incore Power Distribution	Intermediate and HFP	ARO	Power Distribution
ITC	Intermediate to HFP	ARO	Not present
MTC Surveillance	HZP	ARO	Outside scope
Incore Power Distribution	Intermediate and HFP	ARO	Power Distribution
ΔCBC HZP-HFP	HFP	ARO	HZP to HFP Reactivity Difference

[1] Table 1-1 provides descriptions, and Table 1-2 provides the purposes, of the tests discussed in this report.
[2] ANSI refers to the 1997 ANSI standard for reload startup physics tests, Reference 2, which is the source of the information for the ANSI Matrix.

Table C-4 Relationship between Problems in the ANSI and Expanded Problem Detection Matrices

	EXPANDED MATRIX[1] PROBLEM	ANSI MATRIX[2] PROBLEM
4.2.2.1	CEA Worth Error	Analytical Errors
4.2.2.2	CBC Error	Analytical Errors
4.2.2.3	ITC Error	Analytical Errors
4.2.2.4	Power Distribution Error	Analytical Errors
4.2.2.5	MTC Noncompliance	Outside scope
4.2.2.6	SDM Noncompliance	Outside scope
4.2.2.7	Fuel Fabrication Error	Enrichment Error
4.2.2.8	Fuel Misloading	Core Misloading
4.2.2.9	Fuel Distortion	Fuel Assembly Bowing/Damage
4.2.2.10	Fuel Poison Loss	Burnable Poison Loss
4.2.2.11	Fuel Crudding	Excessive Fuel Crudding
4.2.2.12	CEA Fabrication Error	Mechanical Failure/Misloading of Control Rod
4.2.2.13	CEA Misloading	Core Misloading
4.2.2.14	CEA Uncoupling	Mechanical Failure/Misloading of Control Rod
4.2.2.15	CEA Distortion	Mechanical Failure/Misloading of Control Rod
4.2.2.16	CEA Absorber Loss	Loss of Rod Worth
4.2.2.17	CEA Finger Loss	Loss of Rod Worth
4.2.2.18	RCS Anomaly	Flow/Temperature Anomalies
4.2.2.19	RCS B-10 Depletion	Boron (B10) Loss

[1] Definitions and discussions of these problems are provided in the report sections indicated by the number before the problem title.
[2] ANSI refers to the 1997 ANSI standard for reload startup physics tests, Reference 2, which is the source of the information for the ANSI Matrix.

Table C-5 As-Built Core Problem Detection Matrix for Startup Tests

(Effectiveness of test in detecting problem: 1=Good 2=Fair 3=Poor)

[1] Table 1-1 provides descriptions, and Table 1-2 provides the purposes, of the tests discussed in this report.

[2] Definitions and discussions of these problems are provided in the report sections indicated by the number before the problem title.

Table C-6 As-Built Core Problem Detection Matrix for Pre-Operational Activities

(Effectiveness of pre-operational activity in detecting problem; 1=Good 2=Fair 3=Poor)

[1] Discussions of pre-operational activities are provided Section 4.1.

[2] Definitions and discussions of these problems are provided in the report sections indicated by the number before the problem title.

Table C-7 As-Built Core Problem Detection Matrix for STAR Applicability Requirements

(Effectiveness of STAR Applicability Requirements in detecting problem: 1=Good 2=Fair 3=Poor)

[1] Discussions of applicability criteria are provided in Table 3-4.

[2] Definitions and discussions of these problems are provided in the report sections indicated by the number before the problem title.

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APPENDIX D

TEST PERFORMANCE PROBLEM INITIATION

D.1 INTRODUCTION

D.1.1 Background

This appendix describes the development of a matrix that provides the likelihood of various startup tests initiating test performance problems. This matrix uses a three level rating system. Tests are rated as "greatest," "intermediate" or "smallest." The ratings are determined using engineering judgment. This information is used in the test performance problem evaluations in Section 4.3 of this report to determine changes in the likelihood of initiating test performance problems between the Generic and STAR Programs.

D.1.2 Purpose

The purpose of this appendix is to determine the likelihood of startup testing to initiate test performance problems.

D.2 DISCUSSION

Table D-1 presents a problem initiation matrix for startup tests that is based on a review of industry problems and engineering judgment. The identification of test performance problems was based a review of startup test performance activities to determine associated practices that have the potential for causing errors that impact core operation. The following are the test performance problems that are identified for evaluation:

- Test equipment errors
- Test process errors
- Test result errors

In order to evaluate the impact of the test changes on the Generic Program, all the tests involved in both the Generic and STAR Programs need to be considered. This problem initiation matrix addresses all the tests in both the Generic and STAR Programs that are conducted with the reactor critical. Changes from the Generic to STAR Program are also identified. This problem initiation matrix for startup tests provides information for the following subset of tests involved in both the Generic and STAR Programs described in Section 3.0 of this report:

- CBC at HZP
- CEA Worth at HZP
- ITC at HZP
- MTC Surveillance at HZP
- MTC Alternate Surveillance at HZP
- Incore Flux Symmetry at low power

- Incore Power Distribution at intermediate power
- ITC at intermediate to HFP
- MTC Surveillance at intermediate to HFP
- Incore Power Distribution at HFP
- ΔCBC HZP-HFP at HFP

The problem initiation matrix identifies the tests that have a credible likelihood of initiating operation outside the safety analysis. Tests that involve unique operating practices or reactivity maneuvers to support the testing are judged to have a credible likelihood of initiating operation outside the safety analysis. Unique operating practices involving equipment and processes necessary to support testing may cause errors that impact operation. Unique operating practices include the use of a reactivity computer, unique CEA configurations, and the frequent interaction between operations and test personnel on plant operating maneuvers. Normal operating practices involving reactivity maneuvers as part of the test process may also cause errors that impact operation. Normal operating practices include reactivity maneuvers that require changes in CEA position, boron concentration, and temperature. Finally, errors in test results[24] have the potential of impacting plant operation through the substitution of measured values for predicted values in operating instructions. Operating instructions are judged to have a minimal likelihood of initiating operation outside the safety analysis because the test result error would have to involve a significant nonconservative measurement error and be within acceptance criteria for the test. In addition, predicted values rather than measured values are typically used in operating instructions when the test result is less conservative.

Table D-1 rates the likelihood of the various tests in initiating test performance problems as "greatest," "intermediate," or "smallest." This rating is based on engineering judgment and is a relative scale. None of the tests are judged to have a high likelihood of initiating operation outside the safety analysis. Tests involving unique operating practices are judged to have the greatest potential for initiating operation outside the safety analysis and are rated "greatest." Tests involving normal operating practices are judged to be less likely to initiate operation outside the safety analysis and the likelihood is rated as "intermediate." Tests involving operating instructions are judged to have the smallest potential for initiating operation outside the safety analysis and are rated "smallest."

[24] In this evaluation, the impact of the inherent uncertainty associated with the test measurement is not considered to be an error in the test result.

Table D-1 Test Performance Problem Initiation Matrix for Startup Tests

[1] Table 1-1 provides descriptions, and Table 1-2 provides the purposes, of the tests discussed in this report.

[2] Definitions and discussions of these problems are provided in the report sections indicated by the number before the problem title.

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APPENDIX E

PROBLEM EVALUATIONS

E.1 INTRODUCTION

E.1.1 Background

This appendix evaluates the impact of the STAR Program on operation with problems. The effect of the changes to the Generic Program that result from the STAR Program is assessed. The changes to be evaluated are described in Section 3.3 of this report and include both the changes to the tests and the added STAR Applicability Requirements. This evaluation assesses the impact of the changes in the following problem categories:

- Design Prediction
- As-Built Core
- Test Performance

The evaluation determines if the following general evaluation criterion from Section 4.0 of this report is satisfied:

- [

]

Specific evaluation criteria and processes are used for each problem category and are described in Sections 4.1, 4.2 and 4.3 of this report for design prediction, as-built core, and test performance problems respectively.

E.1.2 Purpose

The purpose of this appendix is to evaluate the acceptability of the STAR Program by assessing the impact on problems.

E.2 DISCUSSION

E.2.1 Design Prediction Problem Evaluation

The evaluation process used in this section for design prediction problems[25] is described in Section 4.1 of this report.

E.2.1.1 CEA Worth Inaccuracy

CEA worth inaccuracy is the deviation between the CEA worth predicted by core design methods and the CEA worth actually present in the core. CEA worth inaccuracy is characterized by an uncertainty that is based on deviations between startup test measurements at HZP and core design predictions.

[25] In this evaluation, the impact of the inherent uncertainty associated with the test measurement is not considered to be an error in the test result.

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The impact of the change on CEA worth inaccuracy is determined to be acceptable based on the evaluation criterion being satisfied. This result justifies the use of best estimate CEA worth predictions in lieu of measurements provided the Core Design Applicability Requirements are satisfied. A summary of the impacts on the ability to ensure uncertainties are bounded by the safety analysis is provided in Table 4-1. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.1.2 CBC Inaccuracy

CBC inaccuracy is the deviation between the CBC predicted by core design methods and the CBC actually present in the core. CBC inaccuracy is characterized by an uncertainty that is based on deviations between startup test measurements at HZP and core design predictions.

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A summary of the impacts on the ability to ensure uncertainties are bounded by the safety analysis is provided in Table 4-1. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.1.3 ITC Inaccuracy

ITC inaccuracy is the deviation between the ITC predicted by core design methods and the ITC actually present in the core. ITC inaccuracy is characterized by an uncertainty that is based on deviations between startup test measurements at HZP and core design predictions.

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The impact of the change on ITC inaccuracy is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the ability to ensure uncertainties are bounded by the safety analysis is provided in Table 4-1. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.1.4 Power Distribution Inaccuracy

Power distribution inaccuracy is the deviation between the power distribution predicted by core design methods and the power distribution actually present in the core. Power distribution inaccuracy is characterized by an uncertainty that is based on deviations between startup test measurements at power and core design predictions.

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A summary of the impacts on the ability to ensure uncertainties are bounded by the safety analysis is provided in Table 4-1. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2 As-Built Core Problem Evaluation

The evaluation process used in this section for as-built core problems is described in Section 4.2 of this report.

E.2.2.1 CEA Worth Error

CEA worth error detection is the detection of CEA worth predictions that result from errors in the application of PWR methods. The measured startup test parameters potentially affected when CEA worth errors are present are CEA worth, CBC, ITC and power distribution. CEA worth errors directly affect the CEA worth and significant errors are expected to be detectable. Errors in CEA worth that result from flux distribution errors also affect the power distribution. Related errors in the power distribution may be detectable. Errors in CEA worth that result from neutron absorber errors do not affect the power distribution unless CEAs are inserted. Analytical errors that affect the CEA worth may also affect CBC and ITC although related errors are unlikely to be detectable. These observations on the ability to detect CEA worth errors using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, the core design QA program is effective in detecting CEA worth errors.

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The impact of the change on the detection of CEA worth errors is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.2 CBC Error

CBC error detection is the detection of CBC predictions that result from errors in the application of PWR methods. The measured startup test parameters potentially affected when CBC errors are present are

CEA worth, CBC, ITC and power distribution. CBC worth errors directly affect the CBC and significant errors are expected to be detectable. Errors in CBC that result from reactivity errors also affect ITC. However, related errors in ITC are unlikely to be detectable because changes in CBC are associated with small changes in ITC relative to test criteria. Analytical errors that affect the CBC may also affect the power distribution although related errors are unlikely to be detectable. These observations on the ability to detect CBC errors using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, the core design QA program is effective in detecting CBC errors.

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The impact of the change on the detection of CBC errors is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.3 ITC Error

ITC error detection is the detection of ITC predictions that result from errors in the application of PWR methods. The measured startup test parameters potentially affected when ITC errors are present are CEA worth, CBC, ITC and power distribution. ITC errors directly affect the ITC and significant errors are expected to be detectable. Errors in ITC that result from reactivity errors also affect CBC. Related errors in CBC may be detectable. The test criteria for the MTC that is calculated from the measured ITC may also result in the detection of ITC errors but are less effective than the ITC test criteria. Analytical errors that affect ITC can also affect the CEA worth and power distribution although related errors are unlikely to be detectable. These observations on the ability to detect ITC errors using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, the core design QA program is effective in detecting ITC errors.

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The impact of the change on the detection of ITC errors is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.4 Power Distribution Error

Power distribution error detection is the detection of power distribution predictions that result from errors in the application of PWR methods. The measured startup test parameters potentially affected when power distribution errors are present are CEA worth, CBC, ITC and power distribution. Power distribution errors directly affect the power distribution and significant errors are expected to be detectable. Errors in power distribution can also affect CEA worth. Related errors in CEA worth may be detectable but the measurements are limited to the locations involved in the CEA worth test. Furthermore, the measurements typically involve CEA groups with CEAs in different symmetric locations, which reduces the ability to resolve power distribution differences. Analytical errors that affect the power distribution can also affect CBC and ITC although they are unlikely to be detectable. These observations on the ability to detect power distribution errors using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests.

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The impact of the change on the detection of power distribution errors is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.5 MTC Noncompliance

MTC noncompliance detection is the detection of MTC values that are outside Technical Specification limits. The measured startup test parameters potentially affected when MTC is not in compliance are CBC and ITC. Factors causing MTC noncompliance are likely to be associated with CBC, ITC, and MTC prediction errors. The MTC value used in startup testing is calculated from the ITC using the predicted fuel temperature coefficient. MTC noncompliance is likely to be associated with changes in CBC that affect ITC. The test criteria for MTC are likely to result in the detection of MTC noncompliance because they are established using MTC Technical Specification limits for MTC. The test criteria for ITC may result in the detection of MTC noncompliance but are configured to detect deviations from predictions rather than noncompliance with Technical Specifications. Reactivity changes that affect ITC and MTC also affect CBC and may be detectable. These observations on the ability to detect MTC noncompliance using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, the core design QA and Core Design Applicability Requirements are effective in detecting MTC noncompliance by detecting are CEA worth, CBC, and ITC errors. It is noted that demonstrating Technical Specification compliance using MTC surveillance tests is only one of several methods that are capable of detecting MTC noncompliance.

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The impact of the change on the detection of MTC noncompliance is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.6 SDM Noncompliance

SDM noncompliance detection is the detection of SDM values that are outside Technical Specification limits. This evaluation addresses SDM when the reactor is critical, which may not always be associated with an explicit Technical Specification requirement. The measured startup test parameters potentially affected when SDM is not in compliance are CEA worth, CBC, and ITC. Factors causing SDM noncompliance are likely to be associated with CEA worth, CBC, and ITC prediction errors. CEA worth has the largest impact on SDM and is likely to be the cause SDM noncompliance while CBC and ITC have lesser impacts that affect the power defect. A more negative MTC increases the likelihood of SDM noncompliance by resulting in the addition of more positive reactivity during the cooldown associated with a shutdown from power. The MTC that is calculated from the ITC and compared to Technical Specification limits may be affected. However, a more negative MTC would not exceed the positive MTC test criteria typically used for the MTC surveillance at HZP. The negative MTC test criteria typically used for the MTC surveillance at power may detect SDM problems. These observations on the ability to detect SDM noncompliance using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, the core design QA and Core Design Applicability Requirements are effective in detecting SDM noncompliance by detecting are CEA worth and ITC errors.

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The impact of the change on the detection of SDM Noncompliance is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.7 Fuel Fabrication Error

Fuel fabrication error detection is the detection of as-built fuel characteristics that are different from the intended design. Potentially affected as-built fuel characteristics include enrichment, poison loading, fuel pellet placement and size, fuel rod placement, and poison rod placement. The measured startup test parameters potentially affected by fuel fabrication errors are CEA worth, CBC, ITC and power distribution. Fuel fabrication errors affect the neutronic characteristics of the fresh fuel assemblies and therefore the power distribution. Significant fuel fabrication errors are expected to be detectable in the power distribution. Changes in the power distribution can also affect CEA worth. Related changes in CEA worth may be detectable but the measurements are limited to the locations involved in the CEA worth test. Furthermore, the measurements typically involve CEA groups with CEAs in different symmetric locations, which reduces the ability to resolve power distribution differences. Fuel fabrication errors can also affect core reactivity and related changes on CBC may be detectable. CBC related affects on ITC are not detectable because the predicted ITC is typically corrected for the measured CBC when calculating the deviation between measured and predicted ITC. The MTC that is calculated from the ITC and compared to Technical Specification limits would be affected but the effect is unlikely to be detectable. Fuel fabrication errors may be symmetric and thus may not affect core symmetry. These observations on the ability to detect fuel fabrication errors using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, the fuel fabrication QA is effective in detecting fuel fabrication errors.

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The impact of the change on the detection of fuel fabrication errors is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.8 Fuel Misloading

Fuel misloading detection is the detection of errors in the placement of fuel in the core during core loading. This could involve the placement of fuel in an incorrect location or orientation. The measured startup test parameters potentially affected by fuel misloadings are CEA worth, CBC and power distribution. Fuel misloadings affect the power distribution in the vicinity of the misloading. The effect on the power distribution is more local than global and is likely to be asymmetric. Significant fuel misloadings are expected to be detectable in the power distribution. Changes in the power distribution can also affect CEA worth. Related changes in CEA worth are unlikely to be detectable because the effect is local. CEA worth measurements involve the measurement of multiple locations simultaneously and are limited to the locations involved in the CEA Worth test. Fuel misloadings can also affect core reactivity although related CBC changes are unlikely to be detectable. Any CBC related affects on ITC are judged not to be detectable. These observations on the ability to detect fuel misloadings using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, core verification is effective in detecting fuel misloadings.

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The impact of the change on the detection of fuel misloading is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.9 Fuel Distortion

Fuel assembly distortion detection is the detection of changes in fuel assembly geometry that affect core operating characteristics. Fuel assembly distortions can be the result of operation in the reactor such as bowing, or the result of damage incurred during fuel handling. The measured startup test parameters potentially affected by fuel distortion are CEA drop time and power distribution. Distortions of fuel assembly guide tubes can increase CEA drop time due to mechanical interference or result in the failure to fully insert due to mechanical binding. This is expected to be detectable should it occur, but may not always be a result of fuel distortion. Fuel distortion can also affect the power distribution if fuel rods are displaced or fuel pellets are lost from fuel rods. However, these affects are generally not easily detected because the effects are small and localized. Fuel distortion may be observed during the process of manipulating fuel or may be caused by fuel manipulation. In most instances, the events causing fuel damage or visual observations of apparent anomalies during fuel manipulations result in inspections that detect the actual degradation. The visual inspection of fuel is an effective means of detecting fuel damage but is not part of startup testing. Periodic fuel assembly inspections may be performed but are not a standard pre-operational activity. These observations on the ability to detect fuel distortion using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, if the fuel distortion results in fuel failure, fuel failure is detectable by RCS chemistry monitoring and is accounted for in the safety analysis.

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The impact of the change on the detection of fuel distortion is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.10 Fuel Poison Loss

Fuel poison loss detection is the detection of burnable poison degradation that results in the loss of neutron absorber material. The measured startup test parameters potentially affected by fuel poison loss are CEA worth, CBC, ITC and power distribution. Fuel poison loss affects the power distribution. Significant fuel poison loss is expected to be detectable in the power distribution. Changes in the power distribution can also affect CEA worth. Related changes in CEA worth may be detectable but the measurements are limited to the locations involved in the CEA worth test. Furthermore, the measurements typically involve CEA groups with CEAs in different symmetric locations, which reduces the ability to resolve power distribution differences. Fuel poison loss can also affect core reactivity and related changes on CBC may be detectable. CBC related affects on ITC are not detectable because the predicted ITC is typically corrected for the measured CBC when calculating the deviation between measured and predicted ITC. The MTC that is calculated from the ITC and compared to Technical Specification limits would be affected but the effect is unlikely to be detectable. The fuel poison may be asymmetric because the associated degradation may be somewhat random and core symmetry would also be affected. These observations on the ability to detect fuel poison loss using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests.

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The impact of the change on the detection of power distribution errors is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.11 Fuel Crudding

Fuel crudding detection is the detection of deposits of material from the coolant on the outside of fuel rods. The measured startup test parameters potentially affected by fuel crudding are CBC, CEA worth, and power distribution. One potential effect of fuel crudding is on reactivity is through temperature changes. Fuel crudding reduces heat transfer from the fuel and raises fuel temperature. The increase in fuel temperature reduces local reactivity and flux through fuel temperature coefficient feedback. This reactivity change affects CBC only during power operation and thus affects the change in CBC between HZP and HFP by causing an increase in fuel temperature at HFP.

A second potential effect of fuel crudding is on reactivity through neutron absorption in the crud. This is typically a result of depositing boron on the fuel during nucleate boiling. The increase in neutron absorption reduces local reactivity and can affect CBC at all power levels. The associated flux changes with both types of reactivity changes can affect CEA worth and the power distribution. However, these affects are generally small and not easily detected. In some instances reactivity changes associated with neutron absorption in the crud can be detected in axial flux distributions but is not likely to be detected using startup test criteria. This effect is referred to as the axial offset anomaly (AOA).

These observations on the ability to detect fuel crudding using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. All of the startup tests are ineffective in detecting this fuel crudding. Furthermore, fuel crudding usually develops slowly during operation and is thus not likely to be significant during startup. The effective methods for detecting this problem are the (a) monitoring of RCS pressure drop, flow, temperatures and chemistry during operation, (b) monitoring of the axial distribution for AOA and (c) physical inspection of fuel. In addition, if the fuel crudding results in fuel failure, fuel failure is detectable by RCS chemistry monitoring and is accounted for in the safety analysis.

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The impact of the change on the detection of fuel crudding is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.12 CEA Fabrication Error

CEA fabrication error detection is the detection of as-built CEA characteristics that are different from the intended design. The measured startup test parameters potentially affected by CEA fabrication errors are CEA drop time, CEA drop characteristics (such as trends of drop time by location, slowing in the dashpot, and normal rebound) and CEA worth. Errors in CEA fabrication are unlikely to affect CEA drop time or drop characteristics because of the similar characteristics of CEA materials for different designs. It is unlikely that CEA fabrication errors would affect CEA worth at detectable levels because credible errors in absorber material would result in a small change in CEA worth. Most CEAs are of the similar design, which reduces the potential for interchanges of absorber material that could significantly affect CEA worth. These observations on the ability to detect CEA fabrication errors using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, the CEA fabrication QA is effective in detecting fuel fabrication errors.

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The impact of the change on the detection of CEA fabrication errors is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.13 CEA Misloading

CEA misloading detection is the detection of errors in the placement of CEAs in the core during core loading. This could involve the placement of a CEA in an incorrect location or orientation. The measured startup test parameter potentially affected by CEA misloading is CEA worth. Tests that involve measurements of other parameters are conducted at ARO in both the Generic and STAR Programs. Most CEAs are of the similar design, which reduces the potential for interchanges of CEAs that could affect CEA worth. An interchange that involves two CEAs of different types is unlikely to be detectable, and interchanges involving more than two CEAs are unlikely. CEA misloadings also affect the power distribution in the vicinity of the misloading but this would not be detected by power distribution tests that are performed near ARO. These observations on the ability to detect CEA misloadings using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, core verification is effective in detecting CEA misloadings assuming a verification of CEA type for each CEA location is included.

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The impact of the change on the detection of CEA misloadings determined to be acceptable based on the evaluation criteria being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.14 CEA Uncoupling

CEA uncoupling detection is the detection of the failure to couple a CEA properly, which results in the CEA being inserted in a fuel assembly. The measured startup test parameters potentially affected by CEA uncoupling are CEA drop characteristics, CEA worth, CBC and power distribution. The analysis of CEA drop characteristics such as the drop time for a given location, slowing in the dashpot, and normal rebound is an effective method of detecting CEA uncoupling. CEA uncoupling has a significant effect on the power distribution and is likely to be asymmetric. The increases in power are likely to affect a broad area of the core and thus are likely to be detected using incore detectors. Thus, CEA uncoupling is likely to be detectable in the power distribution. Changes in the power distribution can also affect CEA worth. Related changes in CEA worth are also likely to be detectable because of the significant effect on the power distribution. CEA uncoupling also affects core reactivity and related changes in CBC may be detectable. CBC related affects on ITC are not detectable because the predicted ITC is typically corrected for the measured CBC when calculating the deviation between measured and predicted ITC. The related affects on the MTC that is calculated from the ITC are minor and unlikely to be detectable. These observations on the ability to detect CEA uncoupling using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, CEA coupling verification using acceptance criteria on heights and weights following CEA coupling are effective in detecting CEA uncoupling.

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The impact of the change on the detection of CEA uncoupling is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.15 CEA Distortion

CEA distortion detection is the detection of changes in CEA geometry that affect the ability of CEAs to move as designed. Of particular concern is the ability of CEAs to trip as designed. The measured startup test parameter potentially affected by CEA distortion is CEA drop time. Distortions of CEAs can increase CEA drop time due to mechanical interference or result in the failure to fully insert due to mechanical binding. Mechanical interference and significant impacts on CEA drop time are detectable. The inspection of CEAs using non-destructive examination techniques is an effective means of preventing and detecting CEA distortion but is not part of startup testing. Periodic CEA inspections may be performed but are not a standard pre-operational activity. The most effective method of detecting CEA mechanical interference is by the withdrawal and subsequent tripping of a CEA. These observations on the ability to detect CEA distortion using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests.

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The impact of the change on CEA distortion detection is determined to be acceptable based on there being no changes to the detection methods in the Generic Program. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.16 CEA Absorber Loss

CEA absorber loss detection is the detection of CEA degradation that results in the loss of neutron absorber material. The measured startup test parameters potentially affected by CEA absorber loss are CEA drop time, CEA worth and power distribution. Distortions of CEAs associated with CEA absorber loss can increase CEA drop time due to mechanical interference or result in the failure to fully insert due to mechanical binding. Significant impacts on CEA drop time are detectable. The most effective method of detecting CEA mechanical interference is the withdrawal and subsequent tripping of a CEA. CEA absorber loss reduces CEA worth and significant losses are expected to be detectable. However, the loss of absorber from a single finger in a CEA is unlikely to be detectable. The loss of absorber from multiple fingers in a CEA may be detectable. CEA absorber loss can affect the power distribution if the loss is in CEAs that are inserted during operation, but would not be detectable with typical CEA insertions during startup testing. These observations on the ability to detect CEA absorber loss using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, nondestructive examinations are effective in detecting degradation associated with both CEA absorber loss and precursors to CEA absorber loss such as cracking or strain.

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The impact of the change on the detection of CEA absorber loss is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.17 CEA Finger Loss

CEA finger loss detection is the detection of the physical separation of CEA fingers from CEAs. The separated finger subsequently remains in the fuel while the CEA is withdrawn. The simultaneous loss of a large number of fingers is unlikely. Further, the loss of a CEA finger, should it occur, would likely occur during the operating cycle. The measured startup test parameters potentially affected by CEA finger loss are CEA drop characteristics (such as trends of drop time by location, slowing in the dashpot, and normal rebound), CEA worth, CBC and power distribution. The analysis of CEA drop characteristics is unlikely to detect the loss of a small number of fingers. A small number of lost fingers have a minor effect on the power distribution that is likely to be asymmetric but unlikely to be detectable. Changes in the power distribution can also affect CEA worth. Related changes in CEA worth are also unlikely to be detectable. CEA finger loss also affects core reactivity but related changes in CBC are unlikely to be detectable. CBC related affects on ITC are not detectable because the predicted ITC is typically corrected for the measured CBC when calculating the deviation between measured and predicted ITC. The related affects on the MTC that is calculated from the ITC are likely to be minor and thus unlikely to be detectable. These observations on the ability to detect CEA finger loss using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. In addition, CEA manipulation during refueling may detect CEA finger loss by either visual observation or mechanical interference.

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The impact of the change on the detection of CEA finger loss is determined to be acceptable based on the evaluation criterion being satisfied. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.18 RCS Anomaly

RCS anomaly detection is the detection of anomalous changes in local RCS parameters such as temperature or flow. The measured startup test parameter potentially affected by RCS anomalies is the power distribution. RCS anomalies are likely to cause core asymmetries. These observations on the ability to detect RCS anomalies using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests. Operational surveillances of RCS parameters such as flow, temperature, and pressure drop are more effective than startup tests in detecting RCS anomalies.

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The impact of the change on the detection of RCS anomalies is determined to be acceptable based on there being no changes to the detection methods in the Generic Program. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.2.19 RCS B-10 Depletion

RCS B-10 depletion detection is the detection of the proportion of the isotope B-10 in the RCS boron. The measured startup test parameter potentially affected by RCS B-10 depletion is the CBC. The depletion of B-10 in the RCS requires a higher CBC for a particular set of core conditions and significant depletions are detectable. This observation on the ability to detect RCS B-10 depletion using measured startup test parameters are used in the following evaluation to assess the effectiveness of startup tests.

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The impact of the change on the detection of RCS B-10 depletion is determined to be acceptable based on there being no changes to the detection methods in the Generic Program. A summary of the impacts on the overall effectiveness in detecting as-built core problems is provided in Table 4-2. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.3 Test Performance Problem Evaluation

The evaluation process used in this section for test performance problems is described in Section 4.3 of this report.

E.2.3.1 Test equipment errors

Test equipment errors are errors associated with unique equipment required to support startup testing. The use of unique test equipment constitutes a unique operating practice that may have a credible likelihood of initiating operation outside the safety analysis. Unique operating practices include the use of a reactivity computer.

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The impact of the change on test equipment errors is determined to be acceptable based on the evaluation criterion being satisfied. Furthermore, the criterion is satisfied if any of the tests evaluated as being eliminated are performed as part of startup test program. A summary of the impacts on the likelihood of operation outside the safety analysis is provided in Table 4-3. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.3.2 Test process errors

Test process errors are errors associated with performing the maneuvers that are required to support startup testing. These maneuvers may involve unique operating practices that are not otherwise used during operation as well as normal operating practices and may have a credible likelihood of initiating operation outside the safety analysis. Unique operating practices include unique CEA configurations and the frequent interaction between operations and test personnel on plant operating maneuvers. Normal operating practices include reactivity maneuvers that require changes in CEA position, boron concentration, and temperature.

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The impact of the change on test process errors is determined to be acceptable based on the evaluation criterion being satisfied. Furthermore, the criterion is satisfied if any of the tests evaluated as being eliminated are performed as part of startup test program. A summary of the impacts on the likelihood of operation outside the safety analysis is provided in Table 4-3. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.2.3.3 Test result errors

Test result errors are errors associated with the measured results for parameters from startup testing. These errors can be caused by hardware malfunctions, as well as improper calibration, connection, operation, and reading of equipment used in the test. Although all measurements are subject to error, measurements that involve complex equipment such as the reactivity computer have a greater potential for error. Test result errors have the potential of impacting plant operation through the substitution of measured values for predicted values in operating instructions. Operating instructions are judged to have a minimal likelihood of initiating operation outside the safety analysis because the test result error would have to involve a significant nonconservative measurement error and be within acceptance criteria for the test. In addition, predicted values rather than measured values are typically used in operating instructions when the test result is less conservative.

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The impact of the change on test result errors is determined to be acceptable based on the evaluation criterion being satisfied. Furthermore, the criterion is satisfied if any of the tests evaluated as being eliminated are performed as part of startup test program. A summary of the impacts on the likelihood of operation outside the safety analysis is provided in Table 4-3. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

E.3 CONCLUSIONS

The impact of the STAR Program was determined to be acceptable based on the general evaluation criterion in Section 4.0 of this report being satisfied. A summary of all the impacts associated with the changes to the Generic Program is provided in Table 5-1.

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APPENDIX F

DEVIATIONS FROM GENERIC PROGRAM BY PARTICIPATING PLANTS

F.1 INTRODUCTION

F.1.1 Background

This appendix evaluates the impact of changes to deviations from the Generic Program by Participating Plants. Deviations are startup tests performed by individual plants that are different from the Generic Program. The changes consist of eliminating additional tests or using alternative tests. The evaluation determines if there are any relevant differences between the given plant and the plants for which the Generic Program has been found to be acceptable. The change is considered acceptable if no relevant differences are found. Otherwise, an evaluation of the differences is performed to assess the acceptability of the changes.

F.1.2 Purpose

The purpose of this appendix is to determine if the use the STAR Program by the Participating Plants can be justified without any requirement to perform startup tests that are not part of the STAR Program.

F.2 DISCUSSION

F.2.1 Generic Program Deviations

Individual plant deviations from the Generic Program are identified for the Participating Plants using Table 3-1 and documented in Table F-1. The following list summarizes the Generic Program deviations:

TEST	POWER	RODS	DEVIATION
CEA Drop Characteristics	Shutdown	Moved	Not performed by 2 plants
CEA Flux Change	HZP	Moved	Performed by 4 plants
CBC	HZP	Rodded	Performed by 4 plants
IBW	HZP	Rodded	Performed by 2 plants
SDM Surveillance	HZP	ARO	Performed by 7 plants[26]
CEA Flux Symmetry	HZP	Moved	Performed by 3 plants

F.2.2 Changes to Generic Program Deviations

The changes to the Generic Program deviations are identified in Table F-2 so the impact on the potential problems can be evaluated. The following list summarizes the changes to the Generic Program deviations:

[26] The SDM Surveillance deviations are related to the different practices for using measured data in the calculation of shutdown margin. The use of measured data in this calculation was not based on consistent requirements, and the various practices for using measured data are thus listed as deviations.

TEST	POWER	RODS	CHANGE
CEA Flux Change	HZP	Moved	Eliminated/ Modified[27]
CBC	HZP	Rodded	Eliminated
IBW	HZP	Rodded	Eliminated
SDM Surveillance	HZP	ARO	Eliminated
CEA Flux Symmetry	HZP	Moved	Eliminated

F.3 EVALUATION

F.3.1 Generic Program Deviation Evaluation Process

This section describes the process used to evaluate changes to Generic Program deviations identified above in Section F.2.2. The evaluation process consists of determining if there are any relevant differences between the given plant and the plants for which the Generic Program has been found to be acceptable. The changes are considered acceptable if no relevant differences are found. Otherwise, an evaluation of the differences is performed to assess the acceptability of the changes. The following criterion is used to evaluate the impact of eliminating a deviation:

- [

]

The expanded problem detection matrix in Table C-2 is used to determine the problems that the eliminated test is capable of detecting. Only problems for which the test is rated as "good" or "fair" are considered. Any changes in tests that are rated as "poor" in the ability to detect the problem are not significant. [

]

F.3.2 Generic Program Deviation Evaluation

This section evaluates the impact of eliminating the Generic Program deviations in Participating Plants using the process described in Section F.3.1.

F.3.2.1 Impact of Eliminating or Modifying the CEA Flux Change Test at HZP

Table F-1 identifies the performance of a CEA Flux Change test at HZP as a deviation from the Generic Program for ANO 2, Waterford 3, and SONGS 2 & 3. The CEA Flux Change test is not part of the Generic or STAR Programs. Using the expanded problem matrix in Table C-2, the CEA Flux Change test at HZP has some ability to detect the following problems:

[27] The modified CEA Flux Change test measures a change in startup rate instead of a change in reactivity using the reactivity computer.

[

]

The following reasons were identified for performing this test at these plants:

- At ANO 2 and SONGS 2 & 3 the CEA Flux Change test at HZP is performed to determine if selected CEAs are coupled. This test is performed in addition to the CEA Drop Characteristics test prior to criticality.
- At Waterford 3 the CEA Flux Change test at HZP is performed to determine if all CEAs are coupled. This test is performed instead of the CEA Drop Characteristics test prior to criticality.

The CEA Flux Change test at HZP is an effective means of detecting CEA uncoupling problems. Consequently, the following practices for the use of the CEA Flux Change test at HZP at these plants were found acceptable:

- As a supplement to the CEA Drop Characteristics test prior to criticality to determine if selected CEAs are coupled
- As an alternative to the CEA Drop Characteristics test prior to criticality to determine if all CEAs are coupled

These plants currently use the reactivity computer to perform the CEA Flux Change test. The CEA Flux Change test could be performed using other plant instrumentation by modifying the test to measure changes in startup rate instead of changes in reactivity. This modification of the CEA Flux Change test is acceptable provided the changes in startup rate associated with CEA insertion can be reliably resolved using the instrumentation. Changes in startup rate can be measured using a trend of flux vs. time.

Eliminating the CEA Flux Change test at HZP is acceptable provided the CEA Drop Characteristics test prior to criticality is performed. [

] Therefore the impact of eliminating the CEA Flux Change test at HZP is determined to be acceptable based on the criterion in Section F.3.1 being satisfied. The results of this evaluation of the impact of eliminating or modifying the CEA Flux Change test at HZP are listed in Table 5-2. In addition, the CEA Flux Change test at HZP is determined to be an acceptable alternative to the CEA Drop Characteristics test. It is further determined that modifying the test to measure startup rate instead of reactivity using the reactivity computer is acceptable provided the changes associated with CEA insertion can be reliably resolved on the instrumentation used.

F.3.2.2 Impact of Eliminating the Rodded CBC Test at HZP

Table F-1 identifies the performance of a rodded CBC test at HZP as a deviation from the Generic Program for ANO 2, Calvert Cliffs 1 & 2, and Millstone 2. The rodded CBC test at HZP is not part of the Generic or STAR Programs. Using the expanded problem matrix in Table C-2, the rodded CBC test at HZP has some ability to detect the following problems:

[

] In addition, the unrodded CBC test at HZP has a similar ability to detect problems and is part of both the Generic and STAR Programs. Furthermore, the added ΔCBC HZP-HFP test at HFP has some ability to detect many of the problems in Table C-2 that can be detected by the rodded CBC test at HZP. The impact of eliminating the rodded CBC test at HZP is determined to be acceptable based on the criterion in Section F.3.1 being satisfied. The results of this evaluation of the impact of eliminating the rodded CBC test at HZP are listed in Table 5-2.

F.3.2.3 Impact of Eliminating the IBW Test at HZP

Table F-1 identifies the performance of an IBW test at HZP as a deviation from the Generic Program for St. Lucie 1 &2. The IBW test at HZP is not part of the Generic or STAR Programs. Using the expanded problem matrix in Table C-2, the IBW test at HZP has some ability to detect the following problems:

[

] Therefore the impact of eliminating the IBW test at HZP is determined to be acceptable based on the criterion in Section F.3.1 being satisfied. The results of this evaluation of the impact of eliminating the IBW test at HZP are listed in Table 5-2.

F.3.2.4 Impact of Eliminating the SDM Surveillance Test at HZP

Table F-1 identifies the performance of a SDM Surveillance test at HZP as a deviation from the Generic Program for ANO 2, Waterford 3, Millstone 2, SONGS 2&3, St. Lucie 1, St. Lucie 2 and Ft Calhoun. A SDM Surveillance test is the determination of the SDM using parameters measured as part of startup testing at HZP. The SDM Surveillance test at HZP is not part of the Generic Program because there was no generic practice or general requirement for SDM surveillances at HZP. Section 3.1.2 of this report provides the basis for not including the SDM Surveillance test in the Generic Program. The licensees employed different practices for performing a SDM surveillance at HZP as illustrated in the following summary:

- Two plants did not use startup test measurements
- One plant used measured CBC
- Three plants required an acceptable CEA worth measurement as a prerequisite but used predicted values.
- Two plants adjusted the predicted CEA worth if the measured value is low by 10% or more.
- Two plants adjusted the predicted CEA worth using the measured CEA worth.

The instances in which measured CBC or CEA worth is used in the SDM surveillances were identified as test deviations from the Generic Program. Using the expanded problem matrix in Table C-2, the SDM Surveillance test at HZP has some ability to detect the following problem:

[

] Although some parameters related to SDM are measured as part of startup testing, SDM itself is not measured. In addition, verification of SDM using best estimate predictions is as effective in detecting SDM noncompliance as verifications using measurements when using the STAR Program. [

] Furthermore, Tables C-5, C-6, and C-7 identify the core design QA and the Core Design Applicability Requirements as the most effective means of detecting SDM noncompliance. The Core Design Applicability Requirements added as part of the STAR Program enhance the detection of significant errors in CEA worth and MTC predictions by requiring reconciliation with a previously measured core. In addition, the added ΔCBC HZP-HFP test at HFP is effective in detecting power defect problems that can impact SDM.

At one time the CE Standard Technical Specifications contained a requirement to perform a SDM surveillance prior to exceeding 5% power after fuel loading. This requirement has subsequently been removed from the CE Standard Technical Specifications, and the current version, Reference F-1, contains a requirement to perform a reactivity balance surveillance prior to exceeding 5% power after fuel loading. This requirement is satisfied using the measured CBC and does not require any measurements eliminated by the STAR Program. The SDM surveillances required in the current version of the CE Standard Technical Specifications apply only to shutdown conditions and only require CBC measurements.

[

] Therefore the impact of eliminating the SDM Surveillance test[28] at HZP is determined to be acceptable based on the criterion in Section F.3.1 being satisfied. The results of this evaluation of the impact of eliminating the SDM Surveillance test at HZP are listed in Table 5-2.

F.3.2.5 Impact of Eliminating the CEA Flux Symmetry Test at HZP

Table F-1 identifies the performance of a CEA Flux Symmetry test at HZP as a deviation from the Generic Program for Calvert Cliffs 1 & 2. The CEA Flux Symmetry test at HZP is not part of the Generic or STAR Programs. This test is performed only with CEA group C, and thus involves only one of eight CEA groups. Using the expanded problem matrix in Table C-2, the CEA Flux Symmetry test at HZP has some ability to detect the following problems:

[

]

Three of the eight CEA groups at Calvert Cliffs 1 & 2 contain dual CEAs. There is a greater potential for not detecting CEA uncoupling in dual CEAs because the CEA Drop Characteristics test is less effective in detecting a condition in which one of the two CEAs in a dual CEA is uncoupled. This is because the rod drop trace characteristics such as trends of drop time by location, slowing down in the dashpot, and normal rebound would be less affected. However, it is unlikely that the CEA group C Symmetry test would detect most of these situations and this test is not conducted at other plants with dual CEAs. Using Tables C-5, C-6, and C-7 the CEA coupling verification using heights and weights remains as an effective method of detecting CEA uncoupling. In addition, the Incore Flux Symmetry and Power Distribution tests at power also remain and would likely detect any CEA uncoupling.

The CEA Flux Symmetry test is performed at Calvert Cliffs 1 & 2 to detect fuel misloadings and was based on a previous fuel misloading analysis that credited the use of CEA group C to detect specific misloadings. The current fuel misloading analysis for Calvert Cliffs 1 & 2 does not credit any CEA Flux Symmetry tests at HZP when there are no incore detector problems but does credit the Incore Flux Symmetry and Incore Power Distribution tests at power. The CEA Flux Symmetry test is credited as a contingency in the event of incore detector problems. The current analysis uses the results of a CEOG study that demonstrated the acceptability of eliminating CEA Flux Symmetry tests for CE Plants and evaluated the impact on fuel misloadings. [

] Therefore the impact of eliminating the CEA Flux Symmetry test at HZP is determined to be acceptable based on the criterion in

[28] SDM surveillances that do not use startup test measurements are not considered startup tests.

Section F.3.1 being satisfied. The results of this evaluation of the impact of eliminating the CEA Flux Symmetry test at HZP are listed in Table 5-2.

F.4 CONCLUSIONS

1. It is acceptable to eliminate the following startup tests at the Participating Plants:
   - CEA Flux Change test at HZP provided the CEA Drop Characteristics test is performed
   - Rodded CBC test at HZP
   - IBW Test at HZP
   - SDM Surveillance test at HZP
   - CEA Flux Symmetry test at HZP
2. It is acceptable to use either the CEA Drop Characteristics test or CEA Flux Change test at HZP to verify CEA coupling.
3. It is acceptable to modify the CEA Flux Change test at HZP to measure startup rate instead of reactivity using the reactivity computer.

F.5 REFERENCES

F-1 NUREG-1432, Rev.2, "Standard Technical Specifications Combustion Engineering Plants," June 2001.

Table F-1 Deviations from the Generic Program by Participating Plants

(P = Performed   N = Not performed)

TEST[1]	POWER	RODS	PLANT							
			ANO 2	Waterford 3	Calvert Cliffs 1 & 2	Millstone 2	SONGS 2 & 3	St Lucie 1	St Lucie 2	Ft. Calhoun
CEA Drop Characteristics	Shutdown	Moved		N[2]						N
CEA Flux Change	HZP	Moved	P	P			P			
CBC	HZP	Rodded	P		P	P				
IBW	HZP	Rodded						P	P	
SDM Surveillance	HZP	ARO	P	P		P	P	P	P	P
CEA Flux Symmetry	HZP	Moved			P[3]					

[1] Table 1-1 provides descriptions, and Table 1-2 provides the purposes, of the tests discussed in this report.
[2] Instead of performing the CEA Drop Characteristics test, CEA uncoupling is detected by the performing the CEA Flux Change test for all CEAs.
[3] The CEA Flux Symmetry test is performed with only CEA Group C for the purpose of detecting core misloadings.

Table F-2 Changes to Deviations from the Generic Program by Participating Plants

TEST[1]	POWER	RODS	CHANGES	DESCRIPTION
CEA Flux Change	HZP	Moved	Eliminated/ Modified[2]	Verification of CEA coupling from measurements of reactivity or startup rate changes during CEA movement
CBC	HZP	Rodded	Eliminated	Determination of CBC from chemical analysis of RCS samples
IBW	HZP	Rodded	Eliminated	Determination of IBW from measurements of changes in reactivity and CBC
SDM Surveillance	HZP	ARO	Eliminated	Determination of the SDM using parameters measured as part of startup testing at HZP
CEA Flux Symmetry	HZP	Moved	Eliminated	Determination of the degree of azimuthal asymmetry in the neutron flux from measurements of the variation in CEA Worth from symmetric CEAs

[1] Table 1-1 provides descriptions of the tests discussed in this report.
[2] Modify CEA Flux Change test to measure a change in startup rate instead of a change in reactivity using the reactivity computer.

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