SOUTHERN CALIFORNIA
EDISON
An EDISON INTERNATIONAL℠ Company

Dwight E. Nunn
Vice President

February 23, 2000

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

Subject: **Docket Nos. 50-361 and 50-362**
Proposed Change Number NPF-10/15-508
Control Element Assembly Reactivity Worth Test Methodology
San Onofre Nuclear Generating Station, Units 2 and 3

Gentlemen:

This submittal constitutes Proposed Change Number (PCN)-508 to Facility Operating Licenses NPF-10 and NPF-15 for the San Onofre Nuclear Generating Station, Units 2 and 3, respectively (SONGS 2 & 3).

PCN-508 is a request to provide an option regarding the methodology for measuring the reactivity worth of control element assembly (CEA) groups for SONGS 2 & 3 during Low Power Physics Testing (LPPT) following a refueling. The proposed option involves measuring the worth of approximately 3/4 of the full-length CEA groups each refueling cycle rather than the present methodology, which measures the worth of all full-length CEA groups each refueling cycle. Measured CEA groups would be rotated such that each full-length group would be measured at least every other refueling. Technical objectives of the LPPT will still be achieved with the reduced frequency of testing of selected CEA groups. This change has been determined to involve an unreviewed safety question.

The reduced number of measurements each refueling outage would permit deletion of the "CEA Exchange" test method from LPPT, which would significantly reduce the number of reactivity manipulations and the time duration of operation under the Special Test Exceptions permitted by the Technical Specifications during LPPT. Thus, the proposed methodology option would improve the overall efficiency of the LPPT program without compromising the technical objectives of the testing.

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A001

The proposed LPPT program option would also not require the measurement of inverse boron worth (ppm/%$\Delta\rho$), since its proper value can be inferred from the performance of other tests in the LPPT program.

Details of the proposed methodology options are found in the Enclosure. As documented in the Enclosure, the proposed change is consistent with NRC regulations and industry practices, and does not represent any significant hazards.

Southern California Edison would like to utilize the proposed methodology during the next refueling outage scheduled for October, 2000. We would appreciate a response on this by August 31, 2000.

If you would like additional information regarding this proposed change, please let me know.

Sincerely,

Enclosure

cc: S. Y. Hsu, Department of Health Services, Radiologic Health Branch, State of California
E. W. Merschoff, Regional Administrator, NRC Region IV
L. Raghavan, NRC Project Manager, San Onofre Units 2 and 3
J. A. Sloan, NRC Senior Resident Inspector, San Onofre Units 2 and 3

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Application of SOUTHERN, CALIFORNIA EDISON COMPANY, ET AL. for a class 103 License to Acquire, Possess, and Use a Utilization Facility as Part of Unit No. 2 of the San Onofre Nuclear Generating Station	))))))	Docket No. 50-361 Amendment Application No. 197

SOUTHERN CALIFORNIA EDISON COMPANY, ET AL. pursuant to 10CFR50.59 and 10CFR50.90, hereby submit Amendment Application No. 197. This amendment application consists of a request to conduct a test not described in the safety analysis report which involves an unreviewed safety question. The proposed test would provide optional methodologies for measuring control element assembly reactivity worth and inverse boron reactivity worth.

Subscribed on this 23rd day of February, 2000.

Respectfully Submitted,

SOUTHERN CALIFORNIA EDISON COMPANY

By: [signature]
Dwight E. Nunn
Vice President

State of California
County of San Diego

On 02/23/00 before me, Frances M. Thurber,

personally appeared Dwight E. Nunn, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument the person, or the entity upon behalf of which the person acted, executed the instrument.

WITNESS my hand and official seal.

Signature [signature: Frances M Thurber]

FRANCES M. THURBER
Commission # 1130906
Notary Public — California
San Diego County
My Comm. Expires Mar 23, 2001

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Application of SOUTHERN, CALIFORNIA EDISON COMPANY, ET AL. for a class 103 License to Acquire, Possess, and Use a Utilization Facility as Part of Unit No. 3 of the San Onofre Nuclear Generating Station	))))))	Docket No. 50-362 Amendment Application No. 182

SOUTHERN CALIFORNIA EDISON COMPANY, ET AL. pursuant to 10CFR50.59 and 10CFR50.90, hereby submit Amendment Application No. 182. This amendment application consists of a request to conduct a test not described in the safety analysis report which involves an unreviewed safety question. The proposed test would provide optional methodologies for measuring control element assembly reactivity worth and inverse boron reactivity worth.

Subscribed on this 23rd day of February, 2000.

Respectfully Submitted,

SOUTHERN CALIFORNIA EDISON COMPANY

By: [signature]
Dwight E. Nunn
Vice President

State of California
County of San Diego

On 02/23/00 before me, Frances M. Thurber,

personally appeared Dwight E. Nunn, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument the person, or the entity upon behalf of which the person acted, executed the instrument.

WITNESS my hand and official seal.

Signature [signature]

FRANCES M. THURBER
Commission # 1130906
Notary Public — California
San Diego County
My Comm. Expires Mar 23, 2001

FRANCES M. THURBER
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Enclosure

Evaluation For Proposed Modification to
Low Power Physics Test Program

Evaluation For Proposed Modification to
SONGS Low Power Physics Test Program

SUMMARY

This document evaluates a proposed option to the Low Power Physics Test (LPPT) program at the San Onofre Nuclear Generating Station Units 2 and 3 (SONGS 2 & 3). The proposed option involves reducing the number of full-length control element assembly (CEA) groups measured for reactivity worth each refueling cycle from eight groups (all 83 full-length CEAs) to typically six groups (50-57 CEAs). CEA groups selected for worth measurement would be rotated such that each full-length group would be measured at least every other refueling.

CEA testing contributes toward or fully achieves the following objectives of the LPPT program: (1) validating the adequacy of physics models employed in core design, performance and safety analyses, (2) verifying compliance with Technical Specification shutdown margin requirements, (3) ensuring proper fuel fabrication and reassembly of the reactor core, including CEA coupling, and (4) assuring CEA integrity. The impact of the changes associated with the proposed LPPT program option on these objectives is not significant.

With the reduced number of CEA group worth measurements, the "CEA Exchange" test method is not performed in the LPPT program option. Elimination of the CEA Exchange test method would significantly reduce the number of reactivity manipulations and the time duration of operation under the Special Test Exceptions of the Technical Specifications. The proposed CEA group worth measurement methodology option would therefore improve the overall efficiency, without significantly compromising the technical objectives, of the LPPT program.

The proposed LPPT program option would also not require the measurement of inverse boron worth (IBW, ppm/%$\Delta\rho$), since its proper value can be inferred from the performance of other tests in the LPPT program.

Table 1 provides a summary comparison of key features in the existing and proposed reload physics test programs applicable to the topic of this submittal. It should be noted that specific CEA groups associated with test methodologies identified in the table may vary in each cycle, depending on predicted reactivity worths; typical CEA group selections are provided.

The remainder of this Enclosure provides a detailed technical evaluation of the proposed LPPT changes with respect to reload test objectives, and documents the negative finding with respect to the significant hazards considerations of 10CFR50.92.

Table 1
Comparison of Pertinent Startup Test Elements

Existing Program	Proposed Program	Comments
CEA Drop Time Test	CEA Drop Time Test	No change; eliminates most CEA mechanical concerns
Critical Boron Concentration (CBC)	Critical Boron Concentration	No change
CEA Coupling Check	CEA Coupling Check	No change; ensures CEAs tested are reassembled properly
CEA Worth Measurement by Dilution CEA Groups 5 to 2 (Typical)	CEA Dilution Measurement CEA Groups 5 to 2, OR CEA Groups 5 to 3, and 1 (Typical, in alternate cycles)	Typically, Group 2 or Group 1 would be measured by dilution in alternate cycles, rather than every cycle
Inverse Boron Worth (IBW) by Chemical Analysis	Not required	Proper value of IBW can be inferred from CBC and CEA Group worths
CEA Worth Measurement by Exchange CEA Groups 1, A, & B	Exchange test is not used	Typically, Groups 1 & A, or Groups 2 & B, would be measured in alternate cycles, rather than every cycle, by dilution & boration, respectively
CEA Worth Measurement by Boration CEA Group 6 (Typical)	CEA Worth Measurement by Boration CEA Group 6, and A or B (Typical)	Typically, Group A or B measurement is added to the boration method in alternate cycles
Shutdown Margin (SDM) Verification based on measurement of CEA Groups 6-1, A and B	SDM Verification based on measurement of CEA Groups 6-2 plus B, or Groups 6-3 plus 1 plus A (Typical)	LCS 3.1.101; ratio of measured to predicted CEA worths is used to determine SDM
Power Distribution checks at approximately 3%, 20%, 80% & 100%	Power Distribution checks at approximately 3%, 20%, 80% & 100%	No change

1.0 Introduction

The Reload Physics Test Program, which includes Low Power Physics Tests (LPPT) and Power Ascension Tests (PAT) is performed following each refueling outage to determine if the operating characteristics of the core are consistent with the design predictions, and to provide assurance that the core can be operated as designed.

The present LPPT/PAT program includes (but is not limited to) the following tests:

1) Performing a CEA drop time test, and CEA coupling verifications for all 91 CEAs;
2) Measuring, and comparing against predicted values obtained from physics models:
   a) the initial criticality boron concentration,
   b) the isothermal temperature coefficient,
   c) the inverse boron worth, and
   d) the reactivity worths of all eight of the full-length CEA groups using either the boron exchange method or the CEA exchange method;
      - adequate shutdown margin is then verified using the measured CEA group worths;
      - part-length CEA worths are not measured since they do not contribute to shutdown margin calculations
3) Measuring (using incore instruments and the CECOR code, Reference 9), and comparing against predicted values obtained from physics models, the power distribution at discrete power plateaus during the power ascension to full power.

In the proposed LPPT option, the number of full-length CEA groups whose reactivity worths are measured each refueling is reduced from eight groups to typically six groups, and the CEA exchange test (Reference 8) is not performed. The word "typical" is used throughout this document regarding CEA groups to be tested in the proposed LPPT option since the CEA groups chosen to be tested each cycle may vary slightly, depending on predicted worths. However, CEA groups that are not measured in one refueling outage would be measured in the next refueling outage, and CEA groups tested each cycle would constitute a broad radial distribution of core locations.

Additionally, measurement of the inverse boron worth (ppm boron per %$\Delta\rho$) would not be required in the proposed LPPT option. With acceptable results (i.e., difference between measured values and predicted values is within acceptance criteria) of critical boron concentration and CEA group worths, the value of IBW can be inferred to be also acceptable.

The following detailed evaluation concludes that the proposed LPPT option is consistent with overall LPPT/PAT program requirements and is technically acceptable for implementation. Specifically, the proposed option in CEA worth measurement methodology is shown to be acceptable due to both the inherent design of the CEAs and the history of satisfactorily meeting the acceptance criteria of CEA worth testing.

2.0 Current SONGS 2 & 3 Reload Test Program Description

Key elements of the current SONGS 2 & 3 reload physics test program directly applicable to CEA testing are described below to provide an understanding of the context in which the proposed LPPT option to reduce CEA worth measurements per refueling cycle will occur. (Note that only those elements of the reload physics test program applicable to this discussion are described below.) The description includes the engineering considerations which underlie key test program elements.

2.1 Precritical and Low Power Physics Testing

A. CEA Drop Time and Initial CEA Coupling Verification

Prior to entry into MODE 2, Startup, CEAs are fully withdrawn and then tripped into the core, and the drop times of all 91 CEAs (83 full-length and 8 part-length CEAs) are measured. Measured times are verified to be consistent with safety analysis assumptions and Technical Specification limits.

The CEA Drop Time Test also functions to ensure free travel from the fully withdrawn position to the fully inserted position, actuating their respective rod bottom lights on the core mimic; any deviation from this expectation would result in an investigation.

Data from the CEA Drop Time Test is evaluated statistically against conservative criteria such as acceptable difference of individual drop times from average, acceptable number and height of bounces, and expected slowing at the end of travel (dashpot effect) to identify CEAs that exhibit characteristics of being coupled. CEAs whose data fails any of the acceptance criteria from these checks are identified for further testing to verify proper coupling to their extension shafts.

B. Critical Boron Concentration

Upon achieving criticality, the measured reactor coolant system (RCS) boron concentration is compared to equivalent design expectations. This comparison is used to confirm that overall core reactivity is within design expectations and accepted industry standards. The comparison also provides assurance that soluble boron reactivity worth closely matches design expectations.

C. Subsequent CEA Coupling Check

For pre-selected CEAs and for CEAs that could not be statistically verified to be coupled to their associated extension shafts (see Section A), after achieving criticality, a negative core reactivity response is verified for a typically small CEA insertion. This test verifies that these CEAs are properly coupled to their extension shafts.

D. CEA Worth by Dilution

A boron dilution is initiated following criticality. Compensatory CEA insertions to keep the reactor nearly critical are measured using the reactivity computer (reactimeter); "sawtooth" reactivity trends result from the negative reactivity insertion due to the CEA insertion steps and the positive reactivity insertion due to the dilution. The integrated negative reactivity from CEA insertions is a measure of the total CEA reactivity worth at the existing plant conditions. These measurements are compared directly to predictions. Typically, CEA Groups 5, 4, 3 and 2 (which contain 4, 8, 8, and 9 CEAs, respectively) are measured in the dilution sequence for a total worth of approximately 2100 - 2200 pcm (2.1-2.2%$\Delta\rho$). Group 6 may also be measured by this method if it is sufficiently withdrawn at initial criticality; Group 5 may be measured by boration later in the program if not sufficiently withdrawn at the initiation of the dilution test.

During the CEA worth measurements by dilution, CEA group insertions are required which exceed limits specified by the Technical Specifications. The LPPT Special Test Exception (STE) authorized in the Technical Specifications must therefore be invoked prior to initiation of this test to allow CEAs to be inserted below the normal insertion limits and to reduce the shutdown margin (SDM) below normal requirements. The STE remains invoked until the CEAs are restored to a normal configuration (sequence) and withdrawn above the specified limits (see section H).

E. Inverse Boron Worth (IBW)

After the dilution measurements are complete, RCS boron is allowed to equilibrate. The change in equilibrium boron concentrations from before to after the CEA measurement by dilution is determined. A direct estimate of inverse boron worth (ppm/%$\Delta\rho$) is determined from the change in boron concentration (ppm) divided by the integrated reactivity (%$\Delta\rho$) computed during the dilution measurement of CEA worths.

F. CEA Worth by Exchange (Reference 8)

After RCS boron has equilibrated (see Section E above), an initial CEA Exchange state point of rod position, RCS temperature, reactivity and boron concentration is established. From this state point, other CEA groups are inserted individually (in small increments) while maintaining near critical conditions by the withdrawal of "dilution CEA" groups (groups which were inserted during the dilution measurement). By using

a) the integrated worth curve generated during the dilution measurement and b) corrections for state point differences, the reactivity worth for each exchange group can be inferred. This sequence is repeated for each "exchange group," after which CEA groups are returned to the configuration recorded prior to the exchanges. Typically, CEA Group 1 (8 CEAs), and Shutdown Groups A (18 CEAs) and B (24 CEAs) are measured using the exchange method for a total worth of approximately 3600 - 3800 pcm.

G. CEA Worth by Boration

Following the CEA Worth by Exchange, a boration is initiated. During this boration, a measurement of CEA Group 6 worth (4 CEAs) and Group 5 worth (if necessary) is obtained in a manner similar, but opposite, to that described for dilution measurements - CEA withdrawals which compensate for the boration and maintain the reactor near critical are measured using the reactivity computer. The typical CEA Group 6 worth in this configuration is about 500 pcm.

H. Restoration to Normal CEA Configuration and Shutdown Margin Verification

Following the CEA worth measurements by boration, the CEAs are restored to a normal, near-all-rods-out configuration by further boration and CEA exchange, typically without measurement. At this point, CEAs have been restored to a normal configuration and withdrawn above the limits of the Licensee Controlled Specification Core Operating Limits Report, and the Technical Specification LPPT Special Test Exception (STE) for reduced SDM is exited.

Thus, the reactivity worths of all full-length CEA groups are measured in the current SONGS LPPT program by either dilution, exchange, or boration. The total CEA worth is compared to predicted worth to determine SDM, and to ensure consistency with design expectations and the accuracy of core physics models. Deviations from prediction could be associated with modeling errors, mechanical degradation of the rodlets or significant fuel misloading.

2.2 <u>Power Ascension Testing</u>

A. Low Power Flux Map

As soon as practical after exceeding approximately 3% Rated Thermal Power (RTP), a fixed incore flux map is taken and the raw signal data is reviewed for abnormalities. Although detector signals are too weak at this power level to construct a meaningful power distribution, an elevated local flux associated with a significant fuel fabrication or loading error may be detected, and appropriate measures could be implemented to eliminate unnecessary challenges to fuel integrity.

B. Power Distribution

At approximately 20% power, 80% power, and 100% power, flux maps are taken using the incore detector signals and processed through the Combustion Engineering Core Operating Report (CECOR) program (Reference 9) to determine the core power distribution. This power distribution is compared to a predicted power distribution at similar conditions. The comparison is used to detect possible anomalies which may be associated with fuel misloading, computational errors, or uncoupled CEAs. Criteria are defined to identify unusual discrepancies from predictions and to ensure safe operation to the subsequent power plateau.

C. Azimuthal Tilt Verification

Prior to exceeding 20% power, the Core Operating Limits Supervisory System (COLSS) (Reference 10) calculation of azimuthal tilt is independently verified using the CECOR program and evaluated for any anomalous indications.

3.0 Proposed LPPT Program Option

The proposed option to the LPPT program at SONGS 2 & 3 involves a reduction in the number of CEA groups being measured following each reload. This would be accomplished by typically increasing the number of CEA groups measured by the conventional boron exchange (i.e., dilution and boration) methods in lieu of the "CEA Exchange" method of measurement. The word "typical" is used regarding CEA groups chosen to be tested in the proposed LPPT option since the CEA groups to be tested each cycle may vary slightly, depending on predicted worths. However, CEA groups would be selected such that a broad radial distribution of locations would be tested, and every full-length CEA group would be tested at least every other refueling cycle.

In the existing LPPT program, 5 CEA groups (33 individual control rods) are measured using the dilution or boration method, and 3 CEA groups (50 CEAs) are measured using the Exchange method. In the proposed program option, typically six CEA groups (50 - 57 CEAs) would be measured by dilution or boration each cycle, and two groups would not be measured.

Figures 1 and 2 show a possible selection of CEA groups to be tested using the proposed strategy. In this example, Regulating CEA Groups 6, 5, 4, 3, & 2 and Shutdown Bank B would be measured in "odd" cycles, and Regulating CEA Groups 6, 5, 4, 3, & 1 and Shutdown Bank A would be measured in "even" cycles. Thus, Regulating CEA Groups 6, 5, 4, and 3 would be measured each cycle; CEA Group pairs 2 & B and 1 & A would each be measured only in alternate cycles.

Figure 1
Example of Odd Cycle CEA Group Measurements
Core Locations of CEA Groups 6, 5, 4, 3, 2, and B

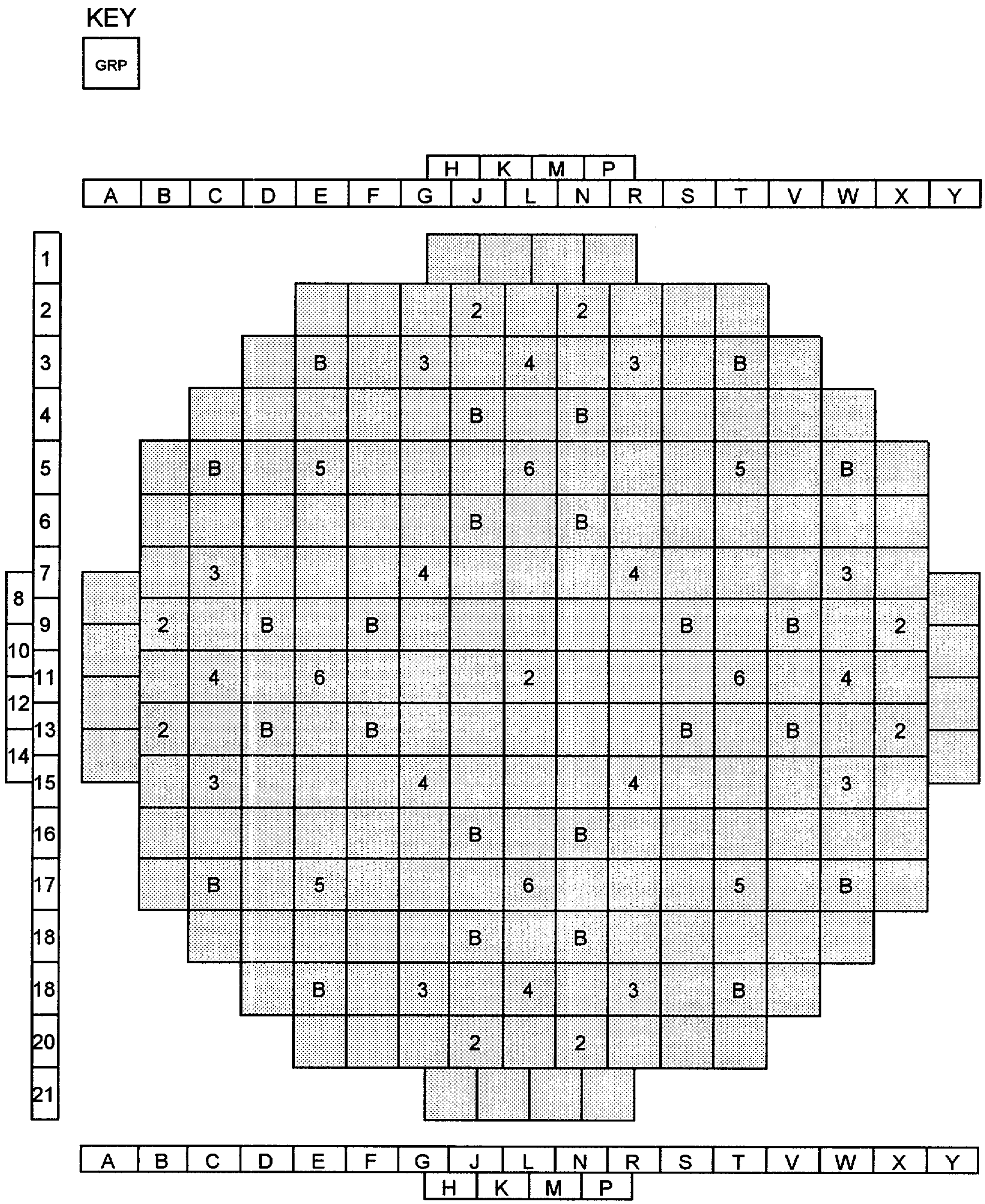
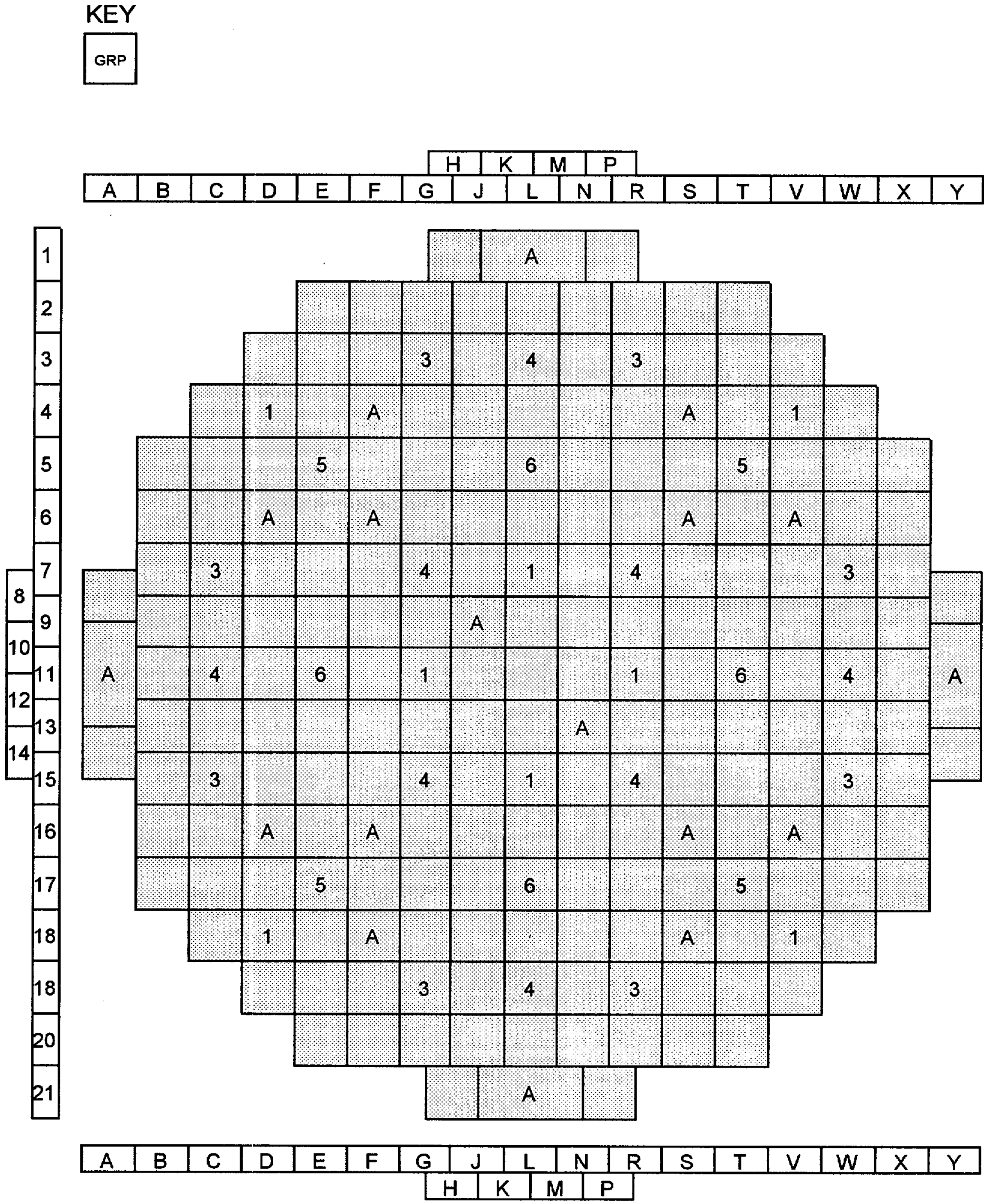


Figure 2
Example of Even Cycle CEA Group Measurements
Core Locations of CEA Groups 6, 5, 4, 3, 1, and A



3.1 Proposed LPPT Program Option Details

The following is a specific discussion of the proposed LPPT program option, consistent with the above example of CEA groups selected for measurement. Again, note that CEA groups selected for worth measurement each cycle may vary, as described earlier.

The proposed LPPT program option test sequence is identical to the present LPPT program up to the CEA worth measurement by dilution. In the proposed typical test sequence option, the CEA worth measurement by dilution would include insertion of Regulating CEA Groups 5, 4, 3, and 2 (the same as the present program), or Groups 5, 4, 3, and 1, in alternating cycles. As with the current LPPT program, CEA Group 6 worth can also be measured by dilution if it is sufficiently withdrawn at the start of the test. Also as with the current LPPT program, the Technical Specifications LPPT Special Test Exception for reduced SDM is required to be invoked prior to initiation of the test.

The next step in the proposed test sequence option is performed soon after the CEA worth measurement by dilution, without necessarily waiting for boron in the Reactor Coolant System to equilibrate with the pressurizer and Chemical and Volume Control System. The insertion of Shutdown Bank B or Shutdown Bank A, in alternating cycles, is exchanged with the withdrawal of the Regulating CEA Groups (in reverse order from the order in which they were inserted), without measurement. This establishes initial conditions necessary for the next test.

Next in the proposed LPPT option: upon the selected Shutdown Bank reaching the fully inserted position, a boration is initiated to measure the Shutdown Bank's worth. Upon withdrawing the selected Shutdown Bank to the fully withdrawn position, Group 6 worth is measured by boration (if not measured by dilution earlier). The order of measuring the worth of the selected Shutdown Bank and Group 6 may be reversed, depending on modeling preferences.

Following the CEA worth measurements by boration, the CEAs are restored to a normal, near-all-rods-out configuration by CEA exchange and/or boration, typically without measurement. At this point, the STE for reduced SDM is exited.

Thus, in the proposed LPPT program option, typically six of eight full-length CEA group worths (50-57 of 83 CEAs) are measured, and only two of the eight full-length CEA group worths (26-33 of 83 CEAs) are not measured - typically either Group 1 or 2 is not measured, AND either Shutdown Bank A or B is not measured. CEA group worths that are not measured during a refueling outage will be measured during the subsequent refueling outage. All CEA group worth measurements are performed using the conventional boration or dilution methodologies, and the CEA exchange test methodology is not utilized. It is expected that the total CEA worth measured each refueling will exceed 3000 pcm.

The proposed LPPT option does not include a requirement to determine inverse boron worth (IBW), since its proper value can be inferred from acceptable results of initial critical boron concentration and CEA group worth. However, IBW may be determined in the proposed LPPT option, typically during the measurement of the Shutdown Bank or Group 6 by boration and/or during the measurement of the Regulating CEA Groups by dilution. During these evolutions, IBW is proposed to be determined based on the boration or dilution rate in gallons per minute (as indicated on the appropriate flow indication), converting this rate to ppm boron per minute based on the estimated RCS boron concentration (estimated using the boronometer or sample results in combination with boration or dilution rates and times), and dividing by the reactivity addition rate (%$\Delta\rho$ per minute) as indicated on the reactimeter. Typically during a dilution or boration measurement, approximately two to four minutes pass between CEA insertions or withdrawals to obtain data for the IBW determination. This provides sufficient time to obtain useful data for the IBW evaluation.

3.2 Comparison of Proposed Rod Worth Testing Option With Industry Standard

ANSI/ANS-19.6.1-1997, Reload Startup Physics Tests for Pressurized Water Reactors (Reference 1) provides an industry standard for rod worth testing. This revision of the ANSI/ANS standard clarifies the definition and type of CEA groups; it also differentiates, based on whether the dilution/boration methodology or some other methodology is used, the minimum CEA group worth to be measured. Specifically, when the dilution or boration method is used, the ANSI/ANS standard states to measure "*control rod groups* [defined below] having a predicted worth of at least 3000 pcm or all of the *control rod groups*." For other test methods, such as the CEA exchange test, the standard states to measure "all rod groups", which is defined as "all [shutdown banks] and *control rod groups*."

The 1997 standard defines "*control rod group*" as "a rod group that may be partially or fully inserted in the core during normal operation." At SONGS, per Core Operating Limits Report Licensee Control Specification 3.1.102, "Regulating CEA Insertion Limits," Regulating Groups 3, 4, 5, and 6 may be partially or fully inserted when the reactor is critical; therefore, these CEA groups are defined by ANSI/ANS 19.6.1-1997 as "*control rod groups*." The proposed LPPT testing option at SONGS will include measurement of CEA Groups 3, 4, 5, and 6 (all "*control rod groups*") each refueling outage; additional CEA group worths (e.g., 2 & B, or 1 & A) will also be measured by dilution or boration such that a total of at least 3000 pcm will be measured by that methodology. Further, all full-length CEA groups will be measured at least every other refueling outage, and CEA groups will be selected to ensure that a broad radial distribution of rod locations is measured each refueling.

Summarizing, the proposed LPPT option approach to rod worth measurement exceeds the associated recommendations of ANSI/ANS 19.6.1-1997 by ensuring that all "control rod groups" will be measured each cycle using the boration or dilution technique, all full-length CEA groups will be measured on at least an alternating cycle, and the total worth of CEA groups measured each refueling is expected to exceed 3000 pcm.

The benefits expected from this option include: a) more efficient use of time both immediately after the initial dilution and during the boration evolutions, b) reduced CEA manipulations, c) simplified reactivity management, and d) reduced duration in the LPPT Special Test Exception to the Technical Specifications.

4.0 Technical Analysis of Proposed Option to Reload Physics Test Program

The proposed LPPT program option employs demonstrated CEA worth measurement techniques which provide reasonable assurance of proper fabrication and reassembly of the reactor core, control rod integrity, adequacy of physics models employed in core design, consistency with safety analysis assumptions and core performance expectations. Although fewer CEA group worth measurements are performed in the proposed program option, the engineering review demonstrates that the reload verification process is not compromised.

The appropriateness of the proposed LPPT option can best be evaluated by examining the objectives for CEA worth measurements and ensuring that these objectives are not compromised by the proposed approach. The specific test objectives associated with CEA worth measurements have included confirmation of:

- CEA coupling to the extension shaft
- Core physics design models
- Shutdown margin and safety analysis assumptions
- Correct core fuel loading
- CEA mechanical performance and integrity
- Inverse boron worth

4.1 CEA Coupling Verification

All 87 five-finger CEAs (full-length and part-length) are uncoupled from their extension shafts each refueling. The four 4-finger CEAs are only uncoupled when their removal from the upper internals is necessary (e.g., for maintenance).

Refueling procedure requirements have been established to ensure proper CEA coupling prior to installation of the reactor head. Nevertheless, the present LPPT program includes checks to identify the possibility of reassembling the reactor following refueling operations with an uncoupled CEA (which did occur during the SONGS Unit 3 Cycle 9 refueling outage in June 1997).

Prior to criticality, a CEA uncoupled from its extension shaft may affect its CEA position indication, including the upper and/or lower electrical limit lights. While unusual CEA position indication led to the identification of the uncoupled CEA at SONGS during the Unit 3 Cycle 9 outage, evaluation of position indications is not a formal requirement of the LPPT program.

Data from the CEA Drop Time Test (required by Technical Specification Surveillance Requirement SR 3.1.5.5), which occurs prior to initial criticality for the cycle, is evaluated statistically to confirm CEAs are coupled to their extension shafts. CEAs are considered to be coupled at this point in the LPPT program if associated drop time test data pass all of the acceptance criteria. CEAs which do not pass all of the acceptance criteria from the drop time test statistical analysis require a post-critical coupling check (see below).

Critical boron concentrations and CEA group worth measurements could identify an uncoupled CEA. However, measurement accuracies of these tests are comparable to the anticipated effect of an uncoupled CEA. Therefore, detection of an uncoupled CEA during these tests is questionable.

Shortly after achieving criticality, a "CEA Coupling Check" is performed on selected CEAs. The coupling check verifies that there is a distinct negative reactivity insertion when the individual CEA is inserted several inches; identification of an uncoupled CEA tested by this methodology is thus ensured. CEAs which, if uncoupled, may not create a sufficiently large flux depression at power to guarantee identification with the radial power distribution check (e.g., low worth CEAs or CEAs which do not have an adjacent operable incore instrument), are presently included in the coupling check irrespective of the results of the CEA Drop Time Test data evaluation. No change to the coupling check methodology is included in the proposed LPPT program option.

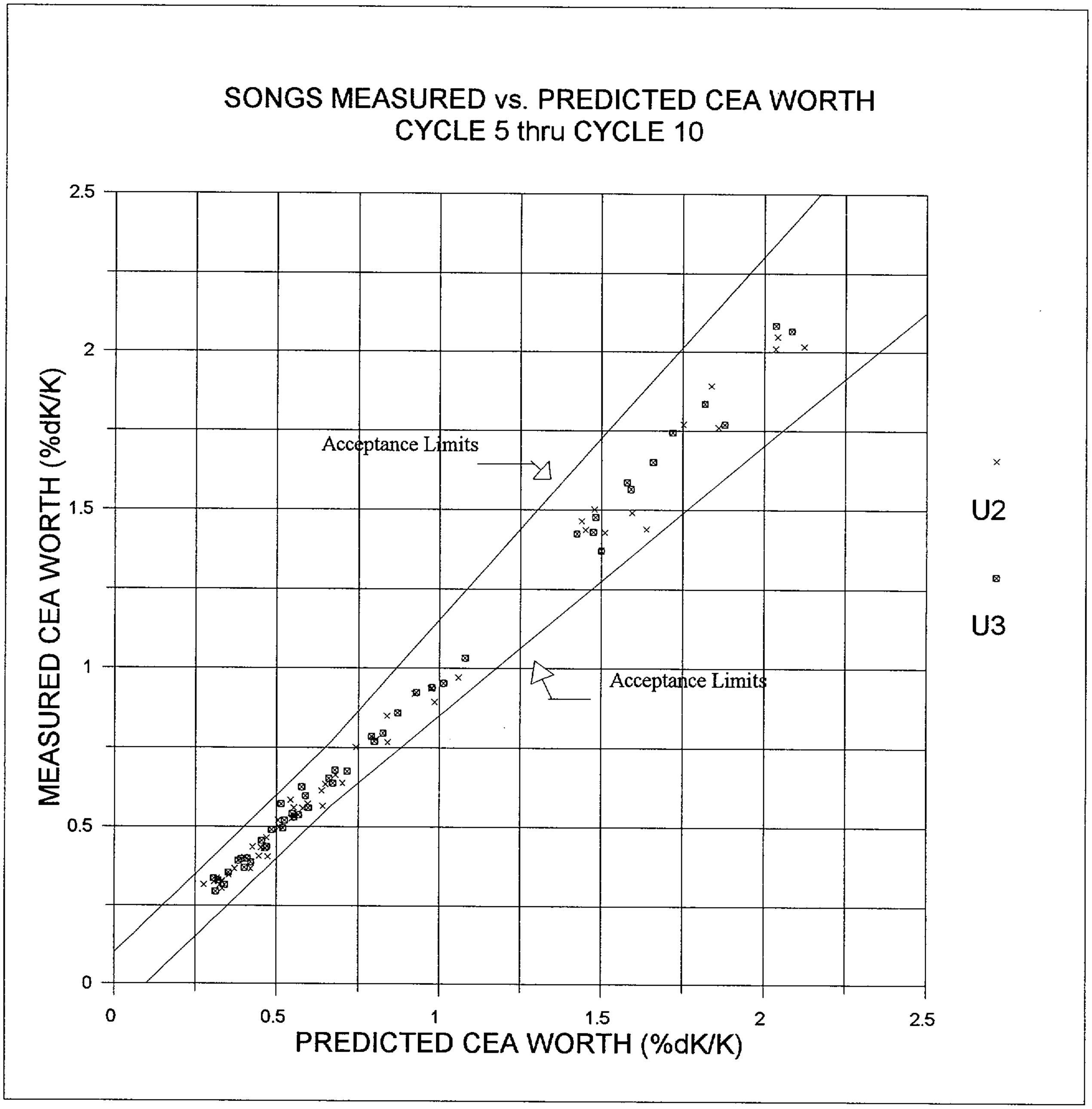
Finally, radial power distribution checks performed during the Power Ascension Test program will identify a flux depression in the area of an uncoupled CEA. Although early, low power (subcritical or critical below the point of adding heat) detection of an uncoupled CEA is ensured by one of the previously mentioned methods, the radial power distribution check provides yet another means to identify an uncoupled CEA.

4.2 Core Physics Design Models Validation

Predictions of control rod worths are among the most important parameters generated by core physics design models. Comparisons between predicted and measured CEA worths after refueling are important to ensure that safety analysis and performance data are reliable.

At SONGS, both SIMULATE (Reference 2) and ROCS (Reference 3) core physics methodologies have been approved by the NRC to generate input to safety and reactor performance analyses. Figure 3 shows a comparison between predicted and measured CEA group worths from cycles 5 through 10 on both SONGS units.

FIGURE 3


SONGS MEASURED vs. PREDICTED CEA WORTH
CYCLE 5 thru CYCLE 10
MEASURED CEA WORTH (%dK/K)
PREDICTED CEA WORTH (%dK/K)
0
0.5
1
1.5
2
2.5
Acceptance Limits
Acceptance Limits
U2
U3

These results include discreet (B_4C shim pin) and distributed (erbium) burnable poison core designs. Individual CEA group test acceptance limits of the greater of 100 pcm or 15% of prediction are also provided on Figure 3 for information. These limits are consistent with industry standards, which are provided in ANSI/ANS-19.6.1-1997, Reload Startup Physics Tests for Pressurized Water Reactors (Reference 1). As can be seen from this comparison, the correlation between predicted and measured CEA group worths has been very good.

Just as it is unnecessary to measure CEA worths at the extreme conditions postulated in the accident analyses, it is also unnecessary to measure every CEA group after refueling in order to ensure that the design models adequately represent the reload cycle. It is very unlikely that the core models would perform acceptably on most CEA locations and yet be inadequate for predicting CEA worth on a specific group, particularly if the measured groups are chosen to represent a broad radial core distribution. This expectation is reflected in the ANSI/ANS-19.6.1-1997 standard for reload physics tests, which does not require all CEA groups to be measured if they are measured by boration or dilution.

4.3 Shutdown Margin (SDM) and Safety Analysis Assumptions Validation

The present LPPT program contains an evaluation of the potential impact of CEA worth measurement results on SDM. The fractional deviation between the total measured and predicted CEA group worths [(measured worth)/(predicted worth)] is applied to adjust the predicted SDM; the adjusted SDM must meet Technical Specification SDM requirements.

In the existing LPPT program, both CEA exchange and dilution/boration measurements are combined for this assessment - the worths of all eight full-length CEA groups are measured and compared against prediction to determine the fractional deviation. In the proposed LPPT option, the fractional deviation will be determined from typically six CEA groups, all of which will be measured by the higher quality dilution or boration methodologies. Also, all full-length CEA groups will be measured at least every other cycle, so the worth of each CEA group will be included in the SDM determination at least every other fuel cycle.

A comparison for SONGS 2 & 3 Cycles 5-10 CEA worth fractional deviations measured by dilution, and measured by dilution and exchange, is provided in Table 2. As can be seen from this table, total measured group worths are in good agreement with predicted values. The table also shows that inclusion of "CEA exchange" measurements adds very little to the overall comparison. The consistency between the "Dilution" and the "Dilution plus Exchange" fractional deviations reflects the dependence of CEA Exchange results on the dilution measurement accuracy.

In summary, the additional information extracted from a complete CEA group measurement using combined CEA exchange and dilution methods does not contribute significantly to the information available in a more limited, dilution-only measurement. Therefore, the proposed LPPT option, which implements expanded dilution/boration measurements, will not compromise the objective of assessing shutdown margin.

Table 2				
Measured fraction of total predicted CEA worth				
Cycle	SONGS 2		SONGS 3	
	Dilution only groups	Dilution plus Exchange	Dilution only groups	Dilution plus Exchange
10	.986	.992	.985	1.000
9	.999	1.015	.964	.981
8	.939	.945	.979	.998
7	.992	1.009	.954	.942
6	.968	.967	1.014	1.014
5	.917	.918	.967	.978

4.4 Verification of Correct Core Fuel Loading

CE NPSD-366 (Reference 4), Verification of Control Rod Integrity and Fuel Symmetry, concluded that comparisons of predicted power distributions with those generated based on incore flux maps are sufficient to identify significant core misloadings. At SONGS 2 & 3, an incore detector flux map is taken shortly after exceeding 3% power, and core flux maps are generated using CECOR at approximately 20%, 80% and 100% power. Criteria for each of these comparison checks are consistent with the incore system capabilities and provide assurance that power may be increased to the next test level without undue risk to the fuel.

CEA group worth measurements do not provide a precise method for detecting a misloaded fuel assembly or fuel fabrication error. The proposed option to the LPPT program at SONGS does not affect the power ascension test program, and therefore does not reduce the capability either to detect a significant fuel loading error or to prevent damage to the fuel. Therefore, the proposed LPPT program option would have no significant impact on the ability to detect a misloaded core.

4.5 Verification of Acceptable CEA Mechanical Performance and Integrity

CEAs at SONGS 2 & 3 are composed of four or five individual rodlets or "fingers" which are permanently attached to a common CEA spider. The CEA spider resides above the fuel and is coupled to an extension shaft. The extension shaft and attached CEA are withdrawn, lowered or tripped by the control element drive mechanism. During refueling, the 79 full-length and the 8 part-length 5-finger CEAs are uncoupled from their extension shafts and are recoupled after the upper reactor vessel internals are restored following refueling. The four 4-finger CEAs are withdrawn into the upper internals during refueling and normally remain coupled to their extension shafts. Each control rod is contained within the fuel assembly guide tube or the CEA shroud of the upper internals. During operation, these components shield the CEAs from the high velocity flow of the core and outlet plenum regions. The fuel assembly CEA guide tubes each displace four fuel rod positions.

Full-length CEA fingers are constructed from an Inconel 625 outer tube containing boron carbide (B_4C) pellets. B_4C pellets are absent in the lower approximately 13 inches of each finger, where silver-indium-cadmium alloy is used to mitigate radiation induced swelling. Part-length CEAs are used for power shape control and employ a solid Inconel segment for neutron poison.

Only full-length CEAs are credited in the safety analysis for reactivity control, and only full-length CEA group worths are measured during startup tests. The reactivity worth of the part-length CEA group is not measured after each refueling since it is not included in the calculation that verifies required shutdown margin is available.

A decrease in the reactivity worth of individual CEA fingers can be postulated as being caused by a small breach in the CEA cladding which results in leaching out of the B_4C into the reactor coolant, or caused by a structural degradation in the CEA finger such that the B_4C pellets escape from the CEA cladding or such that the finger becomes detached from the CEA spider. Such failures may be postulated to be caused by fluence induced swelling of B_4C pellets, external corrosive attack, flow induced fretting, and mechanical distortion of the control rod or host fuel assembly.

Industry experience with detection of deformed CEA fingers, breached CEA cladding or released B_4C pellets has mainly been through CEA insertability, not through CEA worth tests. CEA drop time tests remain an effective means for detection of these types of failures, and are not affected by the proposed LPPT program option. With regard to insertability, CE NPSD-1049-P (Reference 5), Potential for Delayed CEA Insertion Times at CE Designed Plants, states that the design for the interface between the CE (including SONGS 2 & 3) CEAs and fuel assembly guide tubes, in combination with the robustness of their design, is sufficient to preclude these types of problems.

The SONGS 2 & 3 CEA design has been demonstrated to resist the aforementioned types of failure modes over the design life. This is supported by satisfactory performance through seven cycles with the original set of CEAs. In addition, five-finger CEAs have been shuffled during each refueling in accordance with a long term strategy designed to limit any mechanical fretting condition. All control rods were replaced due to design life considerations during the cycle-8 refueling outages at SONGS 2 & 3. No reactivity degradation was observed from the original set of CEAs installed at SONGS 2 & 3.

The reactivity worth of individual CEA fingers is small relative to the CEA group worth. The present LPPT program, while effective at measuring the overall worth of CEA groups, does not include separate worth measurements of individual CEAs, and is therefore expected to be relatively ineffective at identifying changes in the worth of one to several individual CEA fingers. Identification of such changes in the worths of one to several individual CEA fingers, therefore, will not be significantly impacted by measuring a reduced number of CEA groups each refueling outage.

Additionally, the reactivity effect of a degraded CEA finger from which the B_4C is postulated to have leached out or escaped would be expected to be minimized by the neutron shadowing from surrounding intact fingers. With the number of fingers involved in a group worth measurement ranging from 20 to 120, it is unlikely that limited mechanical degradation of one to several CEA fingers would be detected and recognized during LPPT rod worth measurements. Furthermore, the Updated Final Safety Analysis Report (UFSAR, Reference 6) discusses the possible consequence of the release of small quantities of CEA filler materials through failed CEA cladding; the amounts that would be released are too small to have a significant effect on rod worth.

CE NPSD-692-P (Reference 7), Cracked CEA Failure Analysis and Evaluation of Highly Irradiated CEA Materials, documents an evaluation of cracks in CEA cladding which developed in several of the original CEAs at Maine Yankee. All of the affected CEA fingers were center CEA fingers (of a 5-finger CEA), which contained boron carbide pellets essentially to the bottom end cap. None of the outer CEA fingers, which utilized a long Inconel Alloy 625 nose cap and an eight inch long silver-indium-cadmium slug below the boron carbide pellet column, were affected. Recommendations from CE NPSD-692-P, including use of silver-indium-cadmium at the bottom of all CEA fingers, were incorporated into the SONGS 2 & 3 CEA design such that the susceptibility of the SONGS 2 & 3 CEAs to the same failure mode as Maine Yankee CEAs has been greatly reduced.

The estimated reactivity effect of a CEA finger which had separated from its spider assembly would typically be less than 10 ppm (boron equivalent). This is too small to be effectively recognized from critical boron concentration measurements, and would have a similarly small effect on measured CEA group worths.

This failure mode has not been observed to occur with a CEA similar to those used at SONGS 2 & 3. Westinghouse-designed control rods have 10 or more fingers of much smaller physical dimensions. These designs, including SONGS-1, have had occurrence of finger separation from the spider assembly. However, this is not an expected failure mode for the SONGS 2 & 3 CEA design, which includes threaded connections of the rodlets to the spider.

Although CEA group worth measurements remain effective for ensuring that gross reactivity worths are consistent with safety assumptions, power distribution measurements during power ascension testing are the only effective means for identifying this type of CEA failure and precluding potential safety consequences. Core exit thermocouple maps can also provide supporting indication of a dropped CEA finger, but are not routinely taken as part of the present power ascension test program. The proposed LPPT program option does not impact the power ascension test program, and therefore has no impact on the ability to detect a detached or damaged CEA finger.

The proposed LPPT program option would include reactivity worth measurement of typically two full-length CEA groups in alternate cycles, rather than every cycle. If the worth of all CEA groups were to degrade, that condition would be identified in the proposed LPPT program option since typically six of the eight CEA groups will be measured each refueling.

If the reactivity worth of one or both of these untested CEA groups were to degrade without a corresponding degradation in the worth of any of the other CEA groups, then the worth degradation may be unidentified until the next cycle. Such a failure mechanism would necessarily involve degradation of the worth of individual CEA fingers; however, a failure mechanism to cause this situation is expected to be highly unlikely because: 1) the robust design of the SONGS 2 & 3 (Combustion Engineering) CEA and fuel assembly guide tubes greatly reduces or precludes postulated failure mechanisms, 2) the failure mechanism is likely to affect other CEA groups that are tested, so the failure will be identified when those groups are tested, and 3) the failure may be identifiable with the CEA Drop Time test, or during power ascension testing prior to exceeding safety limits.

In conclusion, CEA group worth measurements are of limited value in detecting degraded CEA mechanical performance. The primary defense against mechanical degradation is inherent in the CEA design. SONGS 2 & 3 has taken effective steps to mitigate the potential for degradation by replacing all CEAs during cycle-8 and by maintaining a rotation strategy to minimize and distribute wear. If mechanical degradation or failure of one or more CEAs were to occur, evaluations of power distribution maps and CEA insertion times are the most effective means of detection; these components of reload testing are not affected by the proposed option to the

LPPT program. Therefore, the proposed LPPT program option will not significantly increase the potential for operation with mechanically impaired CEAs.

4.6 Inverse Boron Worth (IBW)

IBW (ppm/%$\Delta\rho$) measurements provide verification that the reactivity worth of soluble RCS boron is consistent with design expectations, and thus contribute to the overall verification of the core physics models used to perform safety analyses.

Excess core positive reactivity is offset by CEA insertion, fission product poisons, dissolved boron, and temperature effects. Agreement between predicted and measured boron concentrations at initial criticality conditions, when CEA insertion and the presence of fission product poisons is minimal, indicates that the worth of soluble RCS boron, and therefore IBW, is also consistent with prediction. Agreement of measured CEA group worths with predicted values further validate the core physics models such that a value of IBW consistent with its predicted value can be inferred.

Since an accurate boron worth of dissolved RCS boron can be inferred with agreement of measured and predicted values of initial critical boron concentration and CEA group worths, performance of an IBW measurement is not required as a separate test in the LPPT program; nevertheless, a method to determine IBW is provided as an option in the present SONGS 2 & 3 LPPT program. The alternate methodology to determine IBW in the proposed LPPT program option is detailed in section 3.1 of this submittal.

5.0 Technical Conclusion

An assessment of the proposed option to the existing SONGS 2 & 3 reload test program has concluded that a) the ability to verify reload test objectives is preserved, b) no unusual test methodologies are employed which could result in plant operation beyond approved limits, c) no unusual test methodologies employ technology which has not been accepted for the proposed application, and d) the overall program minimizes reliance on Special Test Exceptions and untested safety systems.

It is therefore concluded that the proposed test sequence option is technically acceptable for implementation, and would identify any core reactivity modeling error, improper fuel fabrication, improper reassembly of the reactor core, or general degradation in CEA integrity that the present LPPT program would identify.

6.0 No Significant Hazards Considerations:

The Commission has provided standards for determining whether a significant hazards consideration exists as stated in 10 CFR 50.92. A proposed amendment to a facility operating license involves no significant hazards consideration if operation of the facility in accordance with a proposed amendment would not: (1) involve a significant increase in the probability or consequences of an accident previously evaluated; or (2) create the possibility of a new or different kind of accident from any accident previously evaluated; or (3) involve a significant reduction in the margin of safety. The following is a discussion of these standards as they relate to this submittal.

1) Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

No.

The proposed option to the Low Power Physics Test (LPPT) program will involve performance of rod worth measurements of typically six of eight full-length control element assembly (CEA) groups each refueling, rather than performance of rod worth measurements of all eight CEA groups each refueling. Thus, the LPPT option will result in a reduction in the number of plant manipulations required for LPPT. Inverse Boron Worth (IBW) is not required in the proposed LPPT program option, but it may be determined during the performance of a boration or dilution, which is already a part of the present LPPT program. The manipulations which will be performed are a subset of the evolutions which are performed in the existing test sequence. Therefore, the LPPT testing option does not carry any increased risk of any accident evaluated in Chapter 15 of the Updated Final Safety Analysis Report (UFSAR). Since the number and duration of manipulations are reduced, there would actually be a small reduction in accident potential.

The proposed test program option will not compromise the technical objectives of the LPPT program. Fuel fabrication, core and reactor internals reassembly, CEA worths, mechanical integrity and reliability, performance of core physics design codes and consistency with design and safety analysis expectations will remain validated with the same effectiveness as is achieved in the current program. In addition, the reduced duration of operation in the LPPT Special Test Exception of the Technical Specifications has a positive impact on nuclear safety.

Therefore, the proposed LPPT program option does not involve a significant increase in the probability of an accident previously evaluated.

The proposed test program option will eliminate CEA exchange measurements and determine CEA worth by dilution/boration measurements. Measurement of CEA worth by the dilution/boration methods achieves typically higher quality results than the CEA Exchange method.

The proposed LPPT program option does not include the requirement to measure inverse boron worth. However, a measured initial critical boron concentration and measured CEA group worths that match predicted values within acceptance criteria are sufficient to verify adequate core physics modeling without a separate IBW measurement.

Since the proposed test sequence option continues to ensure that core operation and reactivity control are consistent with design expectations, the proposed LPPT option will not involve a significant increase in the consequences of an accident previously evaluated.

Therefore, the proposed LPPT program option does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2) Does the amendment request create the possibility of a new or different kind of accident from any accident previously evaluated?

No.

The proposed LPPT program option does not create any plant condition or manipulation which is materially different from those of the existing program. Furthermore, the number of manipulations and duration of Special Test Exceptions are significantly reduced. The proposed LPPT program option relies entirely on conventional boration and dilution rod worth measurement test methods which have been industry standards. The methodology used to measure IBW, if performed, does not introduce any new evolutions during LPPT and cannot create a new or different type of accident.

Therefore, the proposed LPPT program option does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3) Does this amendment request involve a significant reduction in a margin of safety?

No.

The proposed LPPT program option fully achieves objectives of the reload test program by validating fuel fabrication, core reassembly, CEA worths, mechanical integrity and reliability, performance of physics design codes and consistency with design and safety analysis expectations with the same effectiveness as is achieved in the current program. As a result, all assumptions made in support of UFSAR Chapter 15 Safety Analyses regarding CEA performance remain valid.

The effectiveness of the SONGS 2 & 3 Reload Test program, including LPPT and Power Ascension Testing, has been evaluated and shown to be uncompromised by the proposed LPPT option. Specific testing requirements imposed by the Nuclear

Regulatory Commission are captured in Technical Specification Surveillance Requirements. The proposed LPPT program option is fully compliant with existing Technical Specification Surveillance Requirements and validates the core physics models regarding core performance, reactivity control and proper core reassembly to an extent equivalent to that of the present program.

The proposed LPPT program option is also consistent with the recently modified ANSI/ANS 19.6.1-1997 standard for Pressurized Water Reactor reload testing, with the exception of the requirement and methodology to determine IBW. The ANSI/ANS standard was developed with participation from industry and NRC representatives and represents an expert panel assessment of what is appropriate for an LPPT program. A measured initial critical boron concentration and measured CEA group worths that match predicted values within acceptance criteria are sufficient to verify adequate core physics modeling, and infer that the IBW value is within standard acceptance critieria, without a separate IBW measurement.

Therefore, the proposed LPPT program option does not involve a significant reduction in a margin of safety.

Based on the negative responses to these three Commission criteria, Southern California Edison concludes that the proposed LPPT program option involves no significant hazards consideration.

7.0 <u>Environmental Consideration:</u>

Southern California Edison has determined that the proposed LPPT program option involves no changes in the amount or type of effluent that may be released offsite, and results in no increase in individual or cumulative occupational radiation exposure. As described above, the proposed change involves no significant hazards consideration and, as such, meets the eligibility criteria for categorical exclusion set forth in 10CFR51.22(c)(9).

8.0 References

1. ANSI/ANS-19.6.I-1997, Reload Startup Physics Tests for Pressurized Water Reactors, August 22, 1997

2. SCE-9001-A, Southern California Edison Company PWR Reactor Physics Methodology Using CASMO-3/SIMULATE-3, September 1992

3. SCE-9801-P-A, Reload Analysis Methodology for the San Onofre Nuclear Generating Station Units 2 & 3, June 1999

4. CE NPSD-366, Verification of Control Rod Integrity and Fuel Symmetry, Task 478, November 1987

5. CE NPSD-1049-P, Potential for Delayed CEA Insertion Times at C-E Designed Plants, Task 931, Revision 2, June 1996

6. UFSAR Section 4.2.3.4.D, Potential for and Consequences of CEA Functional Failure

7. CE NPSD-692-P, Cracked CEA Failure Analysis and Evaluation of Highly Irradiated CEA Materials, CEOG Task 666, December 1991

8. ABB-CE (Combustion Engineering) topical report "Control Rod Group Exchange Technique", CEN-319-A, dated June 1986

9. CE NPSD-103-P, CECOR 2.0 General Description, Methods, and Algorithms, June 1980

10. UFSAR Section 7.7.1.5, Core Operating Limit Supervisory System