Startup Test Activity Reduction

STAR Program

Meeting with the NRC
July 17, 2003

Non-Proprietary Slides

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ACRONYM LIST

- ANSI - American National Standards Institute
- ARO - All Rods Out i. e. unrodded operation
- B-10 - A boron isotope with a large neutron absorption cross section
- BOC - Beginning Of Cycle operation
- CASMO/SIMULATE - Core design method developed by Studsvik
- CASMO/(PRISM/XTG) - Core design method used by Advanced Nuclear Fuels / Siemens Nuclear Power
- CBC - Critical Boron Concentration
- Δ CBC - Change in Critical Boron Concentration
- CEA - Control Element Assembly or PWR control rod
- CEOG - Combustion Engineering Owners Group
- DIT/ROCS - Core design method developed by Combustion Engineering
- EOC - End Of Cycle operation
- HFP - Hot Full Power
- HZP - Hot Zero Power
- IBW - Inverse Boron Worth
- ITC - Isothermal Temperature Coefficient
- MOC - Middle Of Cycle operation
- MTC - Moderator Temperature Coefficient
- PHOENIX/ANC - Core design method developed by Westinghouse
- RCS - Reactor Coolant System
- SDM - Shut Down Margin

OVERVIEW

- **Introduction**
  - Purpose
  - Background
- **Startup Test Programs**
  - Generic Program
  - STAR Program
- **Evaluation Overview**
  - Review of Industry Problems
  - Review of Startup Test Results
  - Evaluation Process
- **Design Prediction Problem Evaluations**
- **As-built Core Problem Evaluations**
- **Test Performance Problem Evaluations**
- **Conclusions**

INTRODUCTION

- **PURPOSE**

- **BACKGROUND**

PURPOSE OF STAR PROGRAM

To reduce PWR startup testing activities in accordance with the following objectives:

- **To ensure core can be operated as designed**
  - Added tests
  - Added Applicability Requirements
- **To perform testing using normal plant operating practices**
  - Eliminated reactivity computer
  - Eliminated CEA worth measurements
- **To reduce startup test time**
  - Eliminated ITC measurements using reactivity computer
  - Eliminated CEA worth measurements

BACKGROUND

- **Startup Test Purpose**
  - Ensure core can be operated as designed
    - Detection of core design prediction problems
    - Detection of as-built core problems

- **Startup Test Cost**
  - 8 to 24 hours of lost generation during startup
  - Operations, Chemistry, Reactor Engineering, and analysis support
  - Test performance problems including associated lost generation

- **Startup Test Experience**
  - Good overall agreement between measurement and prediction using modern PWR methods
  - The incidence of design prediction and as-built core problems has been low

- **2001 NRC Meeting**
  - CEOG proposed STAR topical report to eliminate tests that require use of the reactivity computer
  - NRC January 23, 2002 letter encouraged the CEOG to complete STAR project and offered the following for consideration, among others
    - Review of Industry Problems (all PWRs)
    - Review of Startup Test Results (quantitative analysis)
    - Evaluation Process (design prediction and as-built core problems with flowchart)
  - All NRC feedback from the meeting addressed

MEETING WITH NRC ON NOVEMBER 28, 2001

- **Key points from Presentation**
  - Startup testing originally done to benchmark physics codes and to detect "gross" problems
  - Analytical predictions made by modern physics codes are as accurate as test measurements assuming similarity of core designs
  - Topical report will be generic in nature and applicable to PWRs using modern physics methods
  - Generic applicability criteria will be developed for STAR
  - The evaluation is deterministic in nature
  - The evaluation used a qualitative assessment of the effectiveness of startup tests to detect problems

- **Key points from NRC Feedback**
  - Provide a clear explanation of the purpose of startup physics tests
  - Modeling, calculation errors, and as-built core problems will need to be identified and addressed
  - Provide a quantitative analysis of prediction verses measurement for physics parameters important to the evaluation
  - Define the technical basis for justifying/defending test omissions
  - A simple flowchart of the evaluation process will be helpful

- **The staff encouraged the CEOG to complete the STAR project based upon the preliminary assessment of results**

STARTUP TEST PROGRAMS

- **GENERIC PROGRAM**

- **STAR PROGRAM**

OVERVIEW OF STARTUP TEST PROGRAMS

- **Generic Program**
  - Reviewed current design and licensing basis for representative CE plants
  - Identified Generic Startup Test Program
    - Subset of tests typically performed at CE plants
    - Considered an acceptable test program for PWRs
  - Compared startup programs to ANSI recommended program

- **STAR Program**
  - Focuses on elimination of tests in the Generic Program that utilize the reactivity computer
  - Compensatory measures added to ensure the core can be operated as designed
    - Addition of tests not involving reactivity computer
    - Addition of Applicability Requirements
  - Applicable to all PWRs
    - Startup test requirements similar at CE, Westinghouse, and B&W Plants
    - Single ANSI standard applicable to all PWRs

STAR PROGRAM TESTS

- **Eliminated from Generic Program**
  - CEA Worth
  - ITC at HZP
  - MTC Surveillance at HZP

- **Added to Generic Program**
  - Alternate MTC Surveillance at HZP (requires Technical Specification change)
  - ITC at Intermediate to HFP
  - ΔCBC HFP-HZP

- **Unchanged from Generic Program**
  - CEA Drop Time
  - CEA Drop Time Characteristics
  - CBC
  - Incore Flux Symmetry
  - Incore Power Distribution
  - MTC Surveillance at Intermediate to HFP

STAR PROGRAM APPLICABILITY REQUIREMENTS

- **Core Design**
  - [
  -]
- **Fabrication**
  - [
  -]
- **Refueling**
  - [
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- **Startup Testing**
  - [ ]
- **CEA Lifetime**
  - [
  -]

EVALUATION OVERVIEW

- **REVIEW OF INDUSTRY PROBLEMS**
- **REVIEW OF STARTUP TEST RESULTS**
- **EVALUATION PROCESS**

REVIEW OF INDUSTRY PROBLEMS

- **Problem categories**
  - **Design Prediction** problems related to the accuracy of core design methods
  - **As-Built Core** problems related to core anomalies or errors in core design, fabrication, or reassembly
  - **Test Performance** problems related to errors using test equipment, processes, or results

- **Database search for all PWRs**
  - Databases searched
    - NRC Public Document Room (PDR) legacy database (Mid 1970s through 1999)
    - INPO Web Site (Early 1980s to present)
    - Westinghouse Technical Issue database (1979 to present)
    - Participating Plant information
  - Documents found
    - About 5700 documents identified
    - About 450 documents reviewed
    - About 130 documents pertinent to STAR problems

- **Search Results**
  - Only 3 CEA worth prediction problems and no MTC prediction problems were identified
    - Similar CEA worth problems expected to be prevented by the STAR Applicability Requirements
    - Similar CEA worth problems would likely be detected by power distribution monitoring
  - None of the 93 as-built core problems were detected by CEA worth tests
  - Most of the 25 test performance problems involved CEA worth measurements or the reactivity computer

CONCLUSIONS FROM REVIEW OF INDUSTRY PROBLEMS

- **The incidence of significant problems associated with predictions of CEA worth and MTC has been very low. This conclusion is based on the observation that only three CEA worth prediction problems and no ITC or MTC prediction problems were identified in the sample search.**

- **The eliminated CEA worth test at HZP has <u>not</u> been effective in detecting as-built core problems. This conclusion is based on the observation that none of the ninety-three as-built core problems in the sample search were detected by the CEA worth test.**

- **Problems related to tests that involve CEA worth measurements and the reactivity computer at HZP have resulted in operational problems and test delays. This conclusion is based on the observation that most of the twenty-six test performance errors identified in the sample search involved CEA worth measurements or the reactivity computer.**

REVIEW OF STARTUP TEST RESULTS

- **Analysis of CEA worth and ITC data distribution**
  - [

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- **Analysis of CEA worth and ITC data variability**
  - [

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- **Analysis of CEA worth and ITC data poolability**
  - [

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CONCLUSIONS FROM THE REVIEW OF STARTUP TEST DATA

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PROBLEM EVALUATION PROCESS

- **Impact of the STAR Program on the following evaluated:**
  - Problems involving core configurations that are not explicitly accounted for in the safety analysis
  - Deviations from the Generic Program by Participating Plants

- **Problem categories**
  - **Design Prediction** problems related to the accuracy of core design methods
  - **As-Built Core** problems related to core anomalies or errors in core design, fabrication, or reassembly
  - **Test Performance** problems related to errors using test equipment, processes, or results

- **Problem evaluation criteria**
  - [

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  - Specific criteria for each problem category that assures general criterion satisfied

- **Problem evaluation information**
  - Specific information for each problem category related to criteria
  - Basis of evaluation information
    - Industry experience
    - Engineering judgement

PROBLEM EVALUATION FLOWCHART

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DESIGN PREDICTION

PROBLEM EVALUATIONS

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DESIGN PREDICTION PROBLEM EVALUATION PROCESS

- **Four Design Prediction Problems**
  - CEA worth inaccuracy
  - CBC inaccuracy (not impacted by changes)
  - ITC inaccuracy
  - Power distribution inaccuracy (not impacted by changes)

- **Design Prediction Evaluation Criteria**
  - [

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- **Design Prediction Evaluation Information**
  - [

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EVALUATION OF IMPACT ON CEA WORTH INACCURACY

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CONCLUSIONS FROM DESIGN PREDICTION EVALUATION

- **Impact on all design prediction problems determined to be acceptable**
- **Observations related to reliance on predicted values**
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  - The incidence of significant problems associated with predictions of CEA worth and MTC has been very low

AS-BUILT CORE

PROBLEM EVALUATIONS

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AS-BUILT CORE PROBLEM EVALUATION PROCESS

- **Nineteen As-Built Core Problems**
  - Four core design error problems (CEA worth, CBC, ITC, power distribution)
  - Two noncompliance problems (MTC, SDM)
  - Five fuel problems (fabrication, misloading, distortion, poison loss, crudding)
  - Six CEA problems (fabrication, misloading, uncoupling, distortion, absorber loss, finger loss)
  - Two RCS problems (anomaly, B-10 depletion)

- **As-Built Core Evaluation Criteria**
  - [

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- **As-Built Core Evaluation Information**
  - Effectiveness ratings (poor, fair, good) for methods of detecting as-built core problems
    - Startup tests
    - Pre-operational activities
    - STAR Applicability Requirements

EVALUATION OF IMPACT ON MTC NONCOMPLIANCE

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CONCLUSIONS FROM AS-BUILT CORE EVALUATION

- **Impact on all as-built core problems determined to be acceptable**

- **Observations related to eliminating the ITC measurement at HZP**

  - The STAR Program has the same ability to detect problems using ITC and MTC Surveillance tests, although some may be detected at power instead of HZP
    - Most ITC and MTC problems affect CBC and would be detected by the CBC and MTC Alternate Surveillance tests at HZP
  - The STAR Core Design Applicability Requirements enhance the detection of ITC and MTC error problems in the core design process prior to HZP

- **Observations related to eliminating the CEA worth measurement**

  - The STAR Program is expected to detect problems related to the power distribution that would be detected by the CEA worth tests at HZP
  - The STAR Core Design Applicability Requirements enhance the detection of CEA worth error problems in the core design process prior to HZP
  - [

    ]
  - The eliminated CEA worth test at HZP has <u>not</u> been effective in detecting as-built core problems.

TEST PERFORMANCE

PROBLEM EVALUATIONS

TEST PERFORMANCE PROBLEM EVALUATION PROCESS

- **Three Test Performance Problems**
  - Test equipment errors
  - Test process errors
  - Test result errors

- **Test Performance Evaluation Criteria**
  - [

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- **Test Performance Evaluation Information**
  - likelihood (greatest, intermediate, smallest) of startup tests initiating test performance problems

CONCLUSIONS FROM TEST PERFORMANCE EVALUATION

- **Impact on all test performance problems determined to be acceptable**
- **Observations related to eliminating the reactivity computer**
  - Elimination of tests that use the reactivity computer results in startup tests that require only normal plant operating practices
  - Performing startup tests using normal plant operating practices decreases the likelihood of having operational problems associated with testing
  - Problems related to tests that involve CEA worth measurements and the reactivity computer at HZP have resulted in operational problems and test delays

CONCLUSIONS

OBSERVATIONS ON REDUCTIONS IN STARTUP TEST ACTIVITIES

- **Elimination of ITC measurement at HZP**
  - A BOC measurement of of ITC is still performed
- **Elimination of CEA worth measurement**
  - [
  -]
  - A significant reduction in CEA worth due to power distribution problems is detectable by power distribution monitoring
- **Elimination of the reactivity computer**
  - Decreases operational problems

ACCEPTABILITY OF STAR PROGRAM

- **Acceptability based on evaluation of impact on:**
  - Generic Program (evaluation of 26 problems)
  - Deviations from Generic Program by Participating Plants (evaluation of 5 tests)

- **Participating Plants**
  - Implementation of the STAR Program in the Participating Plants is acceptable

- **Non-Participating PWR Plants**
  - Implementation of the STAR Program in the non-participating PWR plants is acceptable provided [ ] that require additional startup testing

- **Other Considerations**
  - A CEA Flux Change test based on either measured reactivity changes or startup rates is an acceptable alternative to the CEA Drop Characteristics test
  - The continued elimination of the MOC at power ITC measurement to verify EOC MTC Technical Specification compliance is acceptable for plants that have already eliminated this measurement in accordance with Amendment 1 to CE NPSD-911-P-A

SUMMARY

- **STAR provides an alternative startup test program that ensures the core can be operated as designed**
  - The ability of the STAR Program to prevent operation with problems is essentially the same as, or better than, the Generic Program
    - Design prediction uncertainties bounded by safety analysis
    - As-built core problems effectively prevented
    - Test performance problems reduced
- **STAR relies on normal plant operating practices for performing startup tests**
  - Reactivity computer eliminated
  - Unique CEA configurations eliminated
- **STAR reduces the time required to perform startup tests**
  - 8 TO 24 EFPHs saved per cycle

MEETING WITH NRC AND THE WESTINGHOUSE OWNERS GROUP REGARDING TOPICAL REPORT WCAP-16011, "STARTUP TEST ACTIVITY REDUCTION PROGRAM"

U.S. Nuclear Regulatory Commission
11555 Rockville Pike, Room T-10F3
Rockville, Maryland 20852
July 17, 2003

MEETING ATTENDEES

NAME (Please Print)	ORGANIZATION	PHONE NUMBER/E-MAIL

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