Westinghouse

A BNFL Group company

Discussion on
Increased Steam Generator Tube Plugging and Reload Methodology at St. Lucie Unit 2 (Transition to WCAP-9272)

Agenda

1. Project Background
2. Licensing Considerations
   2.1. WCAP-9272
   2.2. SER Compliance
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3. Development Phase Overview
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   4.1. Methods
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   4.3. Basics
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      4.3.2. TM/LP & A_1 versus OTΔT & f(Δ I)
5. Core Design – Power Shape Generation, RAOC
6. T/H – Code, Core Limits, Correlation
7. Setpoints Details
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8. RETRAN
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9. Steamline Break
   9.1. Methods Assumptions and Modeling (General)
   9.2. SLB Post-trip LOAC
10. Asymmetric SG transient
11. Feedline Break
12. Documentation Expectations

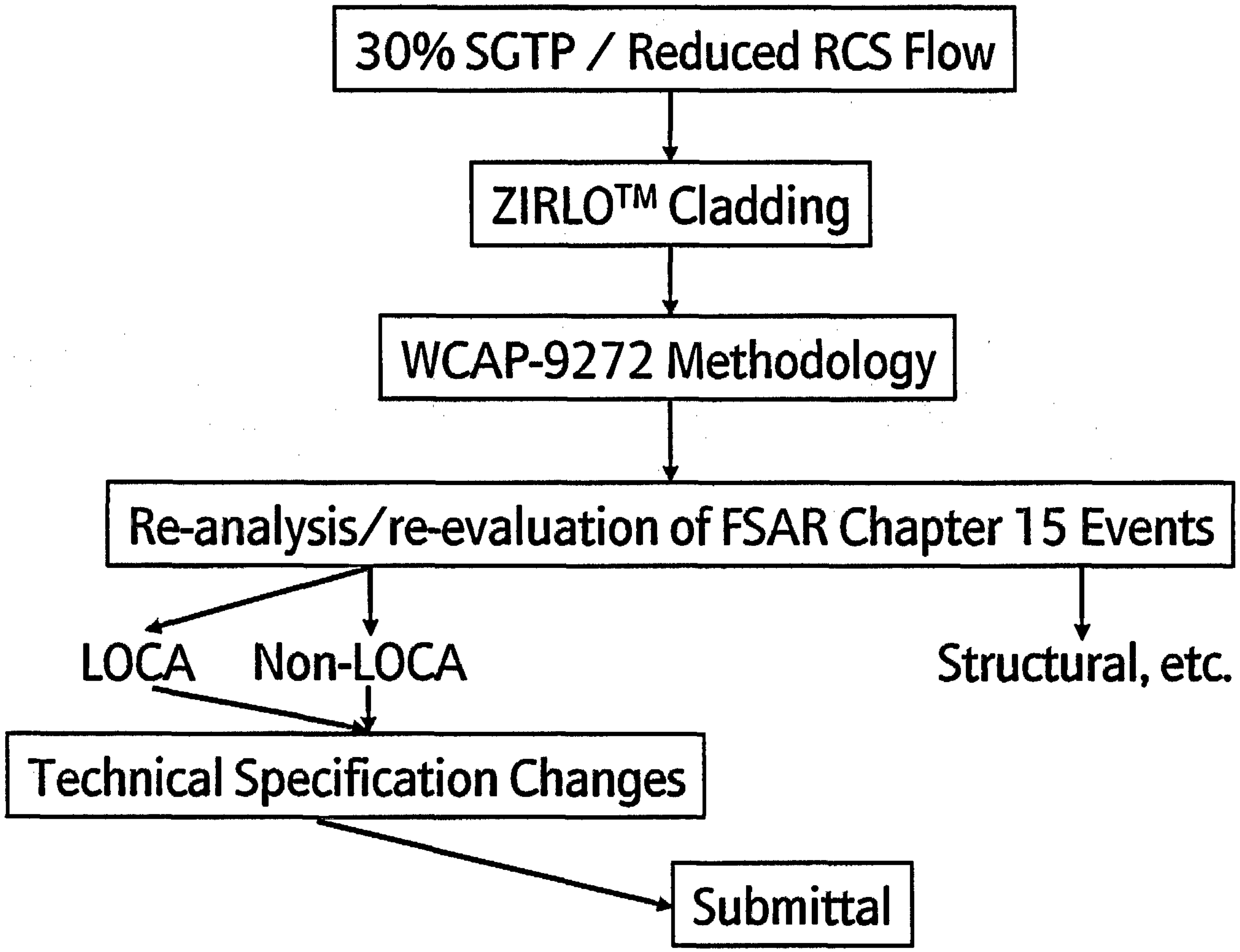
* Additional topics as time permits
* Topics 4 & 7 have been combined and will be presented on Day 2 per NRC's request

Section 1
Project Background

Background

- Background
  - St. Lucie Unit 2:
    - CE NSSS with analog protection system
    - 16 x 16 CE fuel design
    - Nuclear Design by FPL with ALPHA-PHOENIX- ANC
    - Currently uses PAC reload process - CESEC / TORC / FATES / 1985EM / S1M
  - Cycle 15 will support:
    - Increase from 15% to 30% SGTP
    - Reduced TDF (min. TS flow) of 335,000 gpm
    - Transition ZIRLO™ cladding
    - Transition to WCAP-9272 reload Methodology

Program Roadmap



Section 2
Licensing Considerations

Transition to WCAP-9272-P-A Methodology

- Successfully used in reload analysis of over 540 reactor cores (in use since 1985)
- Westinghouse Reload Safety Evaluation Methodology (WCAP-9272-P-A)
  - Defines a bounding approach to the reload evaluation process
  - Defines key safety parameters and their limiting direction
  - Results in a Reload Safety Analysis Checklist (RSAC) approach for reload analysis
  - WCAP-9272-P-A is applicable to both non-Westinghouse and Westinghouse reactors

Transition to WCAP-9272-P-A Methodology

- St. Lucie Unit 2 transition to WCAP-9272-P-A requires all UFSAR Chapter 15 events to be re-analyzed or evaluated (All limiting events would also need to be re-analyzed to support 30% SGTP with associated RCS flow reduction and implementation of ZIRLO™)
- The Westinghouse and CE fuel and plant designs are similar and any minor dissimilarities (i.e., typically input parameters but occasionally a model change) can be accounted for, and do not invalidate the reload methodology applicability or philosophy
- Code, selection, use and applicability will be described, explained and justified

SER Compliance

- All code packages that are planned to be used for FSAR cases have been previously licensed or will be re-licensed as necessary with the NRC
- Selection of code packages will be shown to be applicable to WCAP-9272-P-A
- Principle areas of licensing focus:
  - changes to existing codes and models or new codes and models, and
  - changes to existing methodology or new methodology
    - "New" means new with respect to the "intended application" (i.e., the code/model or method was previously licensed, but has been tailored/customized for the current application)

SER Compliance

- Certain items to be submitted to the NRC for review and approval (see next slide). Since these items would have been previously licensed, the specific licensing application for St. Lucie Unit 2 should be straightforward
- By identifying changes and areas that may need NRC review, the NRC staff will be able to more accurately gauge their resource needs to support the review
- A presentation of changes to existing codes and models or new codes and models and changes to existing methodology or new methodology will be provided in the technical presentations

SER Compliance

Activity	Anticipated NRC Submittal Date	Anticipated NRC Approval Date	Status
Meeting with NRC to Kick-off the Program	4/17	4/27	Completed
Addendum to VIPRE Topical * (WCAP-14565-P-A)	5/03	5/04	Submitted 6/03
Acceptance Meeting for Addendum to VIPRE Topical (WCAP-14565-P-A)	6/03	6/03	Needs to be scheduled
Pre-submittal Meeting with NRC on Licensing Amendment for St. Lucie Unit 2	8/20-21/03	8/20-21/03	Scheduled
Proposed Licensing Amendment for St. Lucie Unit 2 submittal (includes re-write of Chapter 15)	1/04	10/1/04	On-schedule
Acceptance Meeting for St. Lucie Unit 2 submittal	2/04	2/04	Needs to be scheduled

Comparison of Methods

Functional Discipline	Current Code Used	Proposed Code Used	Comments
Core Design	ALPHA/PHOENIX-P/ANC	Same	No change
Thermal-hydraulic Design	TORC	VIPRE	Addendum submittal for incorporating ABB-NV & ABB-TV into VIPRE (Submitted 06/2003)
Correlation	CE-1/ABB-NV	ABB-NV	Upgrade correlation with ABB-NV which is NRC-accepted for referencing in applications for the St. Lucie Unit 2 fuel design
Fuel Rod Design	FATES-3B	Same	No change
Transient Analysis (non-LOCA)	CESEC/STRIKIN-II/ TORC/COAST	RETRAN/FACTRAN/ VIPRE/TWINKLE	Change is within the flexibility of the codes to model both Westinghouse and CE NSSS
Large Break LOCA	85EM	99EM	Upgrade to 99EM which is NRC-accepted for referencing in applications for CE NSSS
Small Break LOCA	S1M	S2M	Upgrade to S2M which is NRC-accepted for referencing in applications for CE NSSS

WCAP-9272 Reload Safety Analysis Checklist (RSAC)

- As noted previously, the reload analysis is based on a reference analysis as documented in a licensee's FSAR
  - These analyses cite the key input assumptions and key input parameters that have the most significant impact on a particular event and specify the corresponding codes and methods used
  - These key input parameters form the basis of Westinghouse's analysis for the particular plant (i.e., these key input parameters and other input parameters form the basis of a Safety Analysis Checklist (SAC), or "Baseline Neutronics")
  - The SAC (or Baseline Neutronics) becomes the Reload Safety Analysis Checklist (RSAC) for subsequent reload analyses/evaluations

Section 3
Development Phase Overview

Process

- General Approach
  - Apply standard Westinghouse WCAP-9272 approach, recognizing:
    - Where changes are required to provide a technically appropriate modeling of the unique features of the St. Lucie Unit 2 design, operations and Tech Specs
    - Where licensing or other considerations warrant a different approach

Process

- General Approach
  - Do not assume that the current licensing basis assumptions apply to WCAP-9272 approach or that WCAP-9272 conventional wisdom applies to St. Lucie 2
    - Study each event using first principles to develop strategies and key assumptions for each event
  - Do the homework first

St. Lucie Unit 2 - Licensing Basis

- Objectives
  - Review and understanding of the licensing basis
    - Expert meeting June 2002
  - Review and understanding of the unique features of the St. Lucie Unit 2 design, Tech Specs and operations
  - Identification of methods to be used, and the basis for these choices
  - Evaluation of the differences between the current basis and the basis arising from the change in methodology
  - Identification of key assumptions for the project technical activities

St. Lucie Unit 2 - Licensing Basis

- Objectives
  - Development of technical and licensing strategies for scoping activities, definition of event requirements (cases), and outlines for methods structured around the standard methods for the technologies being used
  - Outline the production phase of the project in which the analyses and evaluations supporting the January 2004 submittal would be performed

- Extensive study was made of the current St. Lucie Unit 2 licensing basis
  - Experts meeting – June 2002
  - Review of analysis basis material

Comparisons of Current and Transition Methods

- Comparisons of Current and Transition Methods were undertaken
  - Intra-disciplinary meetings to share information, requirements and map preliminary analysis strategies
  - Inter-disciplinary meetings to address interface requirements and consistency of assumptions and strategies

- Technical Strategies were mapped for each event and reviewed for technical and licensing appropriateness
  - Engineering Review – February 2003

Comparisons of Current and Transition Methods

Continuation of Current Methods

- LOCA
- Fuel Performance
- Mechanical Design
- Steam Generator Tube Rupture
- Containment analysis

Comparisons of Current and Transition Methods

Margin Considerations

- A preliminary assessment of margin was performed for key events where 1) historical margin challenges existed, or 2) changes in methods or assumptions made margin evaluation indeterminate to provide confidence in the viability of the transition

Comparisons of Current and Transition Methods

Identification of Key Assumptions

- Based on the technical strategies and the methods requirements, key assumptions were identified and confirmed between FPL and Westinghouse
  - Includes changes in some assumptions based on margin considerations (elimination of full power positive MTC, etc.)
  - The strategies for analysis were identified and refined through consultation with FPL, especially in areas of noteworthy differences
    - Setpoints/ Uncertainties
    - Full power MTC
    - Significant changes in analysis methodology

Overview of Engineering Review

- Focus on
  - Aspects for which changes from the current licensing basis
  - Proposed changes from standard methods to address the unique features of the St. Lucie Unit 2 design, Tech Specs and operations
- The presentations which follow are structured around the Engineering Review material, updated to reflect completed actions and results where available

Section 4 & 7
Reload Setpoints Overview & Setpoint Details

Introduction

- Westinghouse and St. Lucie Thermal Margin Protection Functions

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Design Basis for Thermal Margin Trips

- Design Basis for OTΔT and TM/LP Reactor Trip Functions
  - Ensures that the DNB design basis is satisfied for a wide range of RCS temperatures, pressures, powers and axial power shapes
  - Ensures that vessel exit boiling is precluded to ensure that ΔT is proportional to power

Inputs for Thermal Margin Trips

- OTΔT and TM/LP Trip Functions Based on the following Inputs
  - Power (ΔT as indicated by hot minus cold leg temperature in each loop)
  - Temperature indication (OTΔT => Tavg, TM/LP => Tinlet)
  - Pressurizer pressure (range limited by low and high pressure trips)
  - Axial Shape as defined by excore detectors (OTΔT => top minus bottom TM/LP => Bottom minus top divided by total power)

Thermal Margin Trip Equations

- Westinghouse Overtemperature ΔT Reactor Trip function:

$$\text{Power} = K1 - K2\,(T_{avg} - T_{avg}') + K3\,(P - P') - f(\Delta I)$$

$$\text{Sample: Power} = 1.35 - 0.018\,(T_{avg} - 588') + 0.0085(P\text{-}2250) - f(\Delta I)$$

- St. Lucie TM/LP Reactor Trip function:

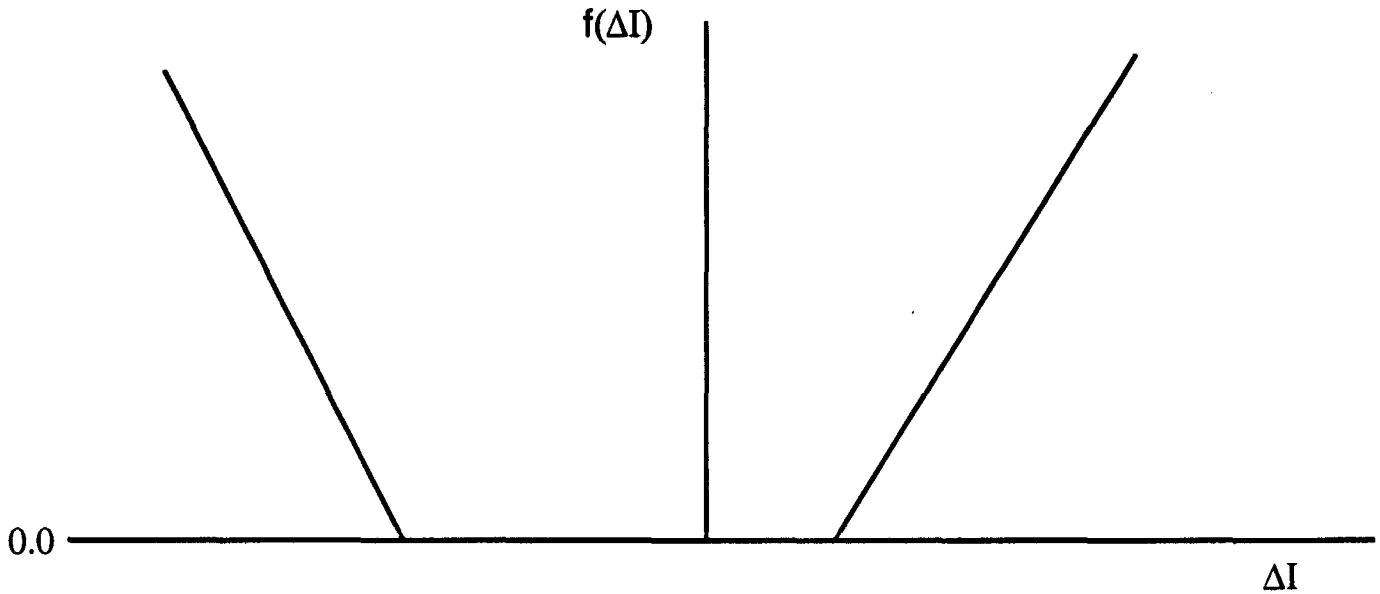
$$P_{var} = 1400 \times Q_{DNB} + 17.85 \times T_{in} - 9410$$

$$\text{where } Q_{DNB} = QR_1 \text{ function} \times A_1 \text{ function}$$

$$\text{Rearranging: Power} = \frac{1.33 - 0.01275\,(T_{inlet} - 549) + 0.000714\,(P - 2250)}{A_1}$$

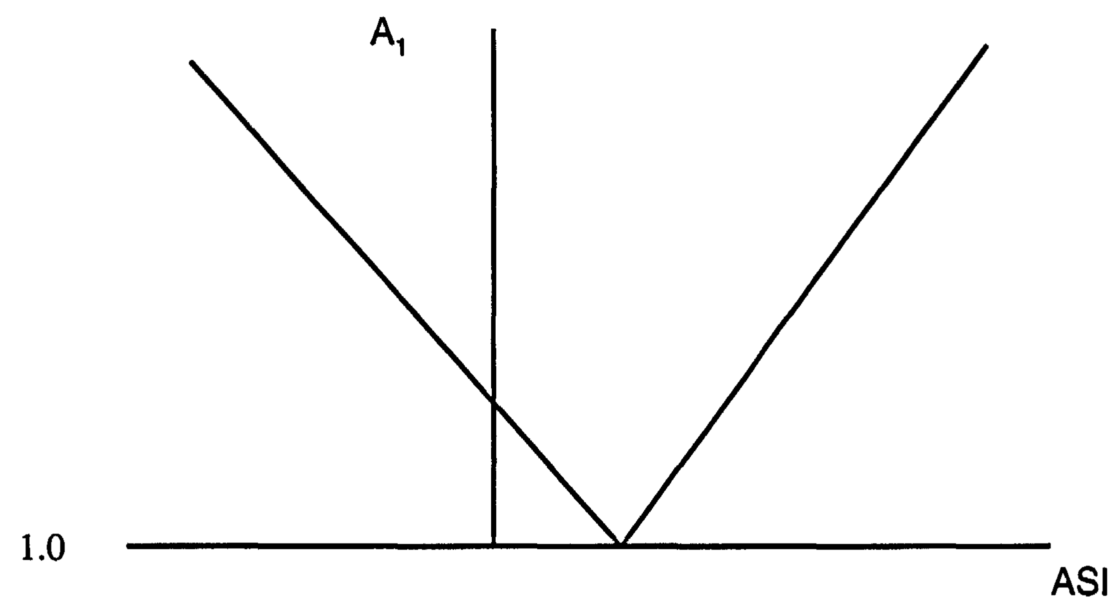
Thermal Margin Trip Equations

- Westinghouse Overtemperature ΔT $f(\Delta I)$ Function
  - Reduces the setpoints for skewed axial power shapes based on top minus bottom excore signal (ΔI)



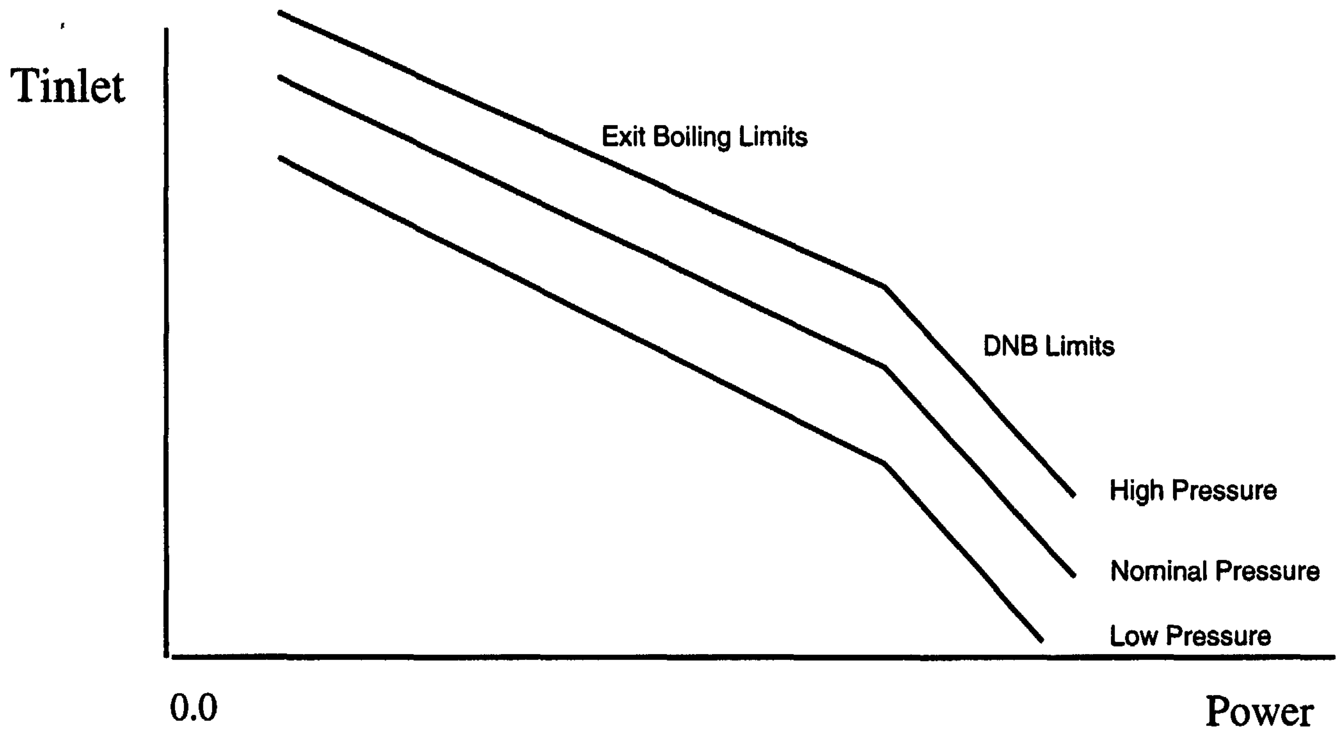
Thermal Margin Trip Equations

- St. Lucie Thermal Margin / Low Pressure A_1 Function
  - Reduces the setpoints for skewed axial power shapes based on bottom minus top excore signal divided by total (ASI)



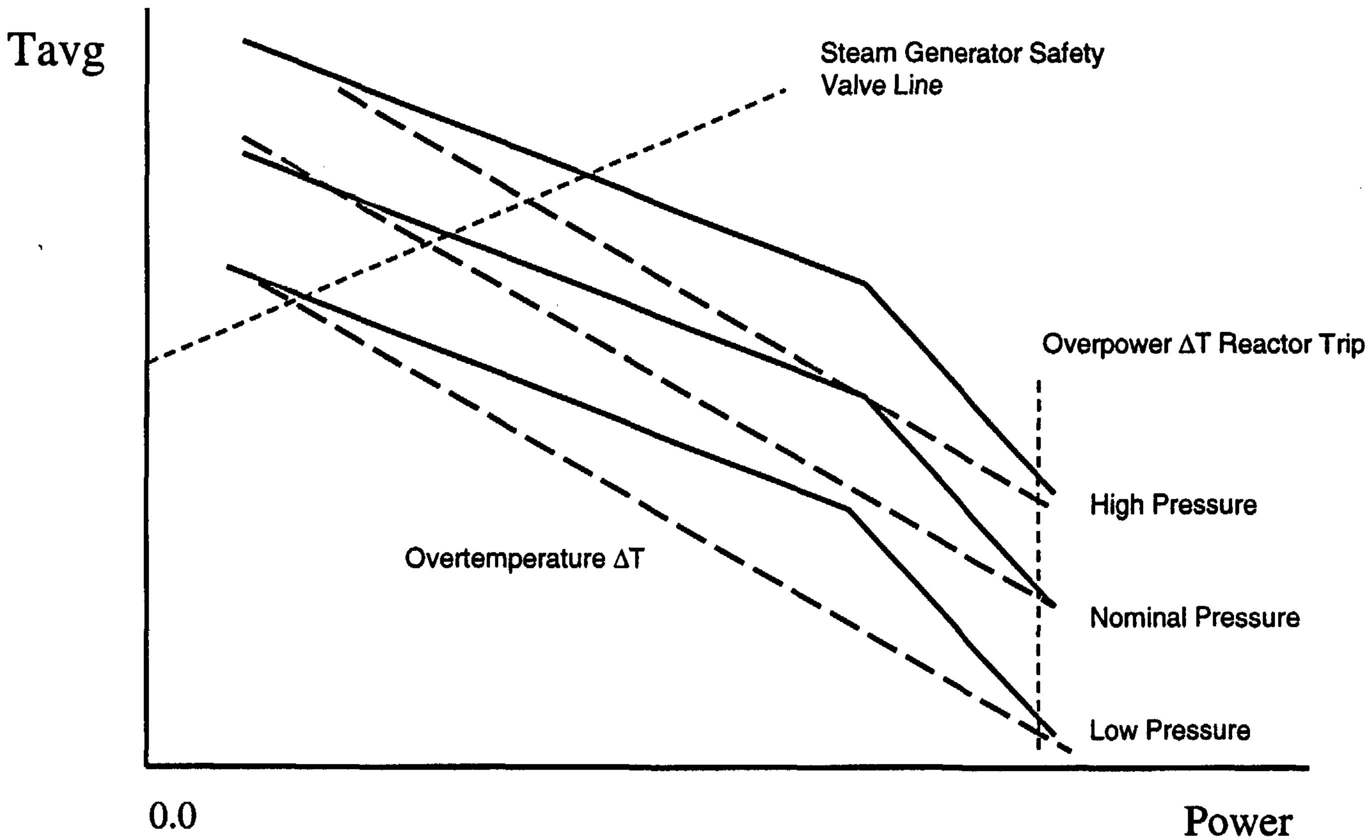
Core Thermal Limits

- Core Thermal DNB Limits
  - Westinghouse assumes a reference axial power shape (1.55 Chopped Cosine) to generate the OTΔT setpoint



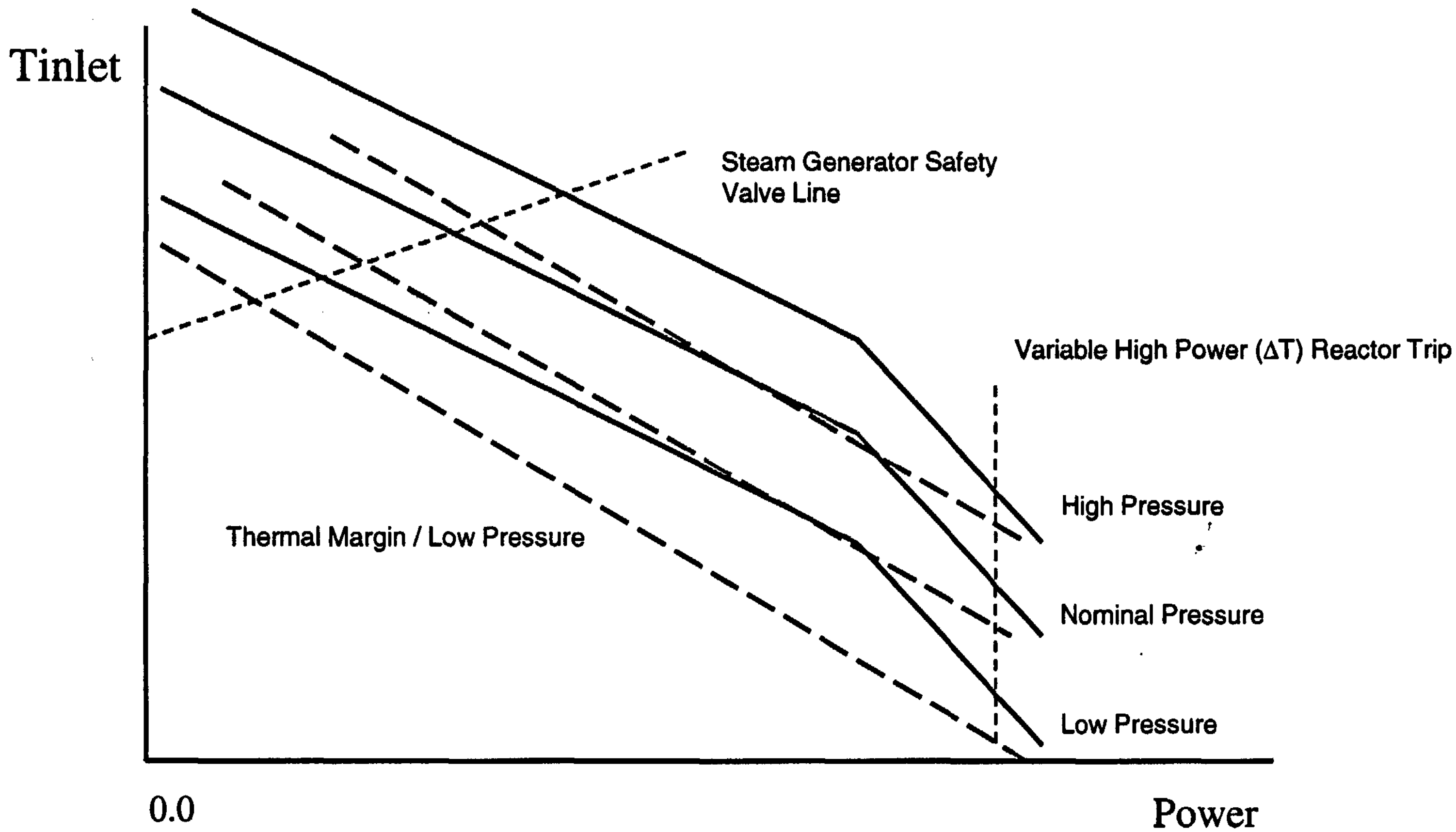
OTΔT Reactor Trip & Core Thermal Limits

- Illustration of OTΔT reactor trip with f(ΔI) = 0 [No penalty]



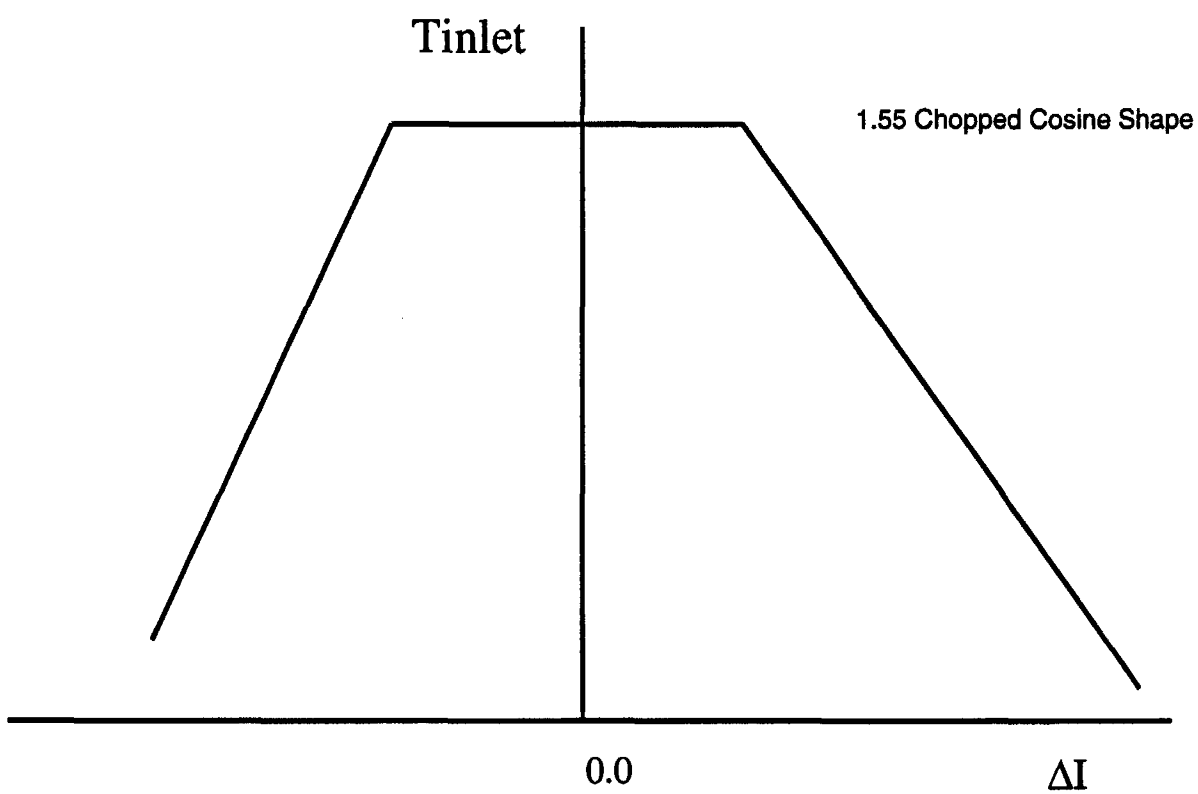
Setpoints: TM/LP Reactor Trip & Core Thermal Limits

- Illustration of TM/LP reactor trip with $A_1 = 1.0$ [No penalty]



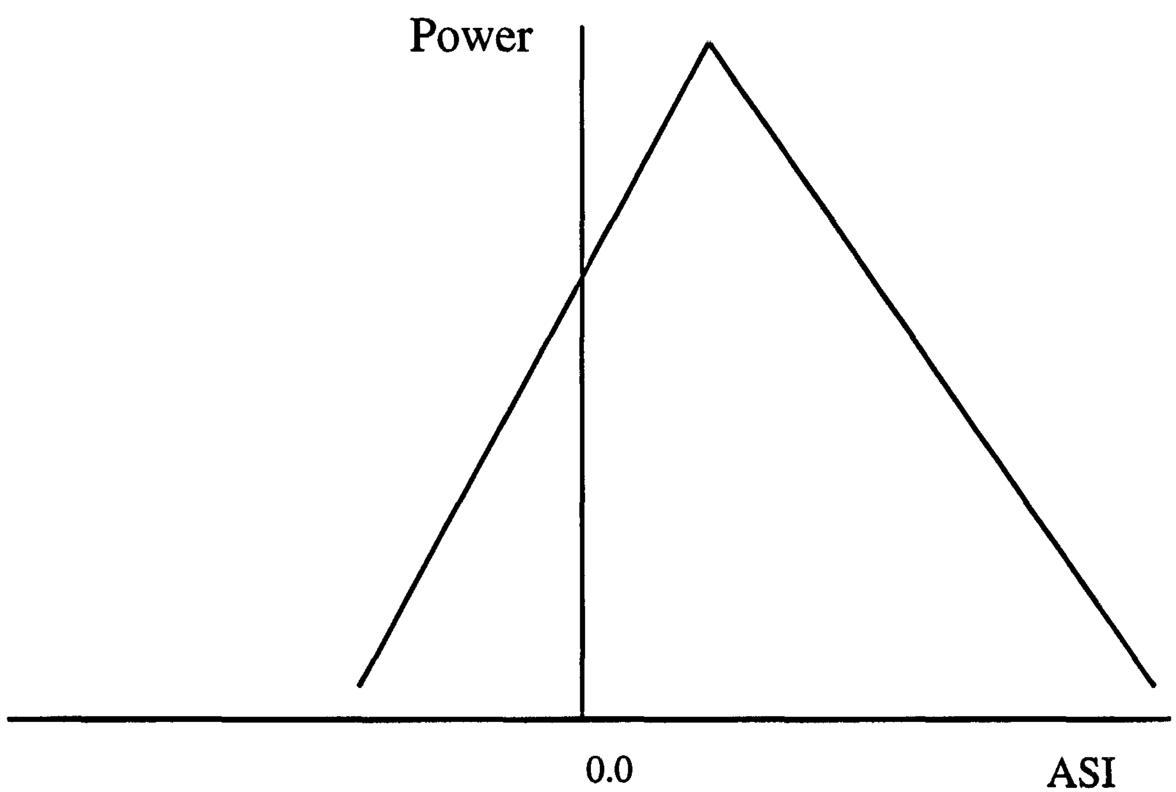
OTΔT Core Thermal Limits for Skewed Shapes

- Locus of Conditions where DNBR is at the limit
  - Used to define the OTΔT f(ΔI) reset function



TM/LP Core Thermal Limits for Skewed Shapes

- Locus of Conditions where DNBR is at the limit
  - Used to define the TM/LP A_1 function



Check of the TM/LP Reactor Trip Function

Core thermal limits, which include both DNB and exit boiling limits, are generated for a wide range of power levels and pressures

The TM/LP reactor trip function, with a bounding ESCU Penalty Factor incorporated into the QR_1 function and a gamma bias supported by the CEA withdrawal at power event (~175 psi), is determined

The TM/LP trip noted above bounds the core limits from the low pressure trip setpoint to the high pressure trip setpoint, for temperatures/ powers from the steam generator safety valves to a power of 120%

Setpoints: TM/LP Trip Function ESCU Penalty Factor

The uncertainties accounted for in the current ESCU Penalty Factor analysis remain unaffected by the switch to the WCAP-9272 philosophy.

ESCU Uncertainties included in ESCU Penalty Factor:

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Setpoints: Other Reactor Trip Functions

The following compares other reactor trip functions.

St. Lucie Unit 2	Vogtle (Westinghouse plant)
Variable High Power - High (107% of RTP)	High Neutron Flux - High (109% of RTP)
Variable High Power - Minimum (15% of RTP)	High Neutron Flux - Low (25% of RTP)
Pressurizer Pressure - High (2370 psia)	Pressurizer Pressure - High (2400 psia)
Pressurizer Pressure - Low (TM/LP 1900 psia)	Pressurizer Pressure - Low (1975 psia)
Reactor Coolant Flow - Low (95.4%)	Reactor Coolant Flow - Low (90%)
Steam Generator Pressure - Low (626 psia)	Steam Generator Pressure - Low SI (600 psia)
Steam Generator Level - Low (20.5% NRS)	Steam Generator Level - Low (35% NRS)

Section 5
Core Design – Power Shape Generation, RAOC

RAOC Condition I

- Standard 1D axial model generation

- RAOC EVALUATION

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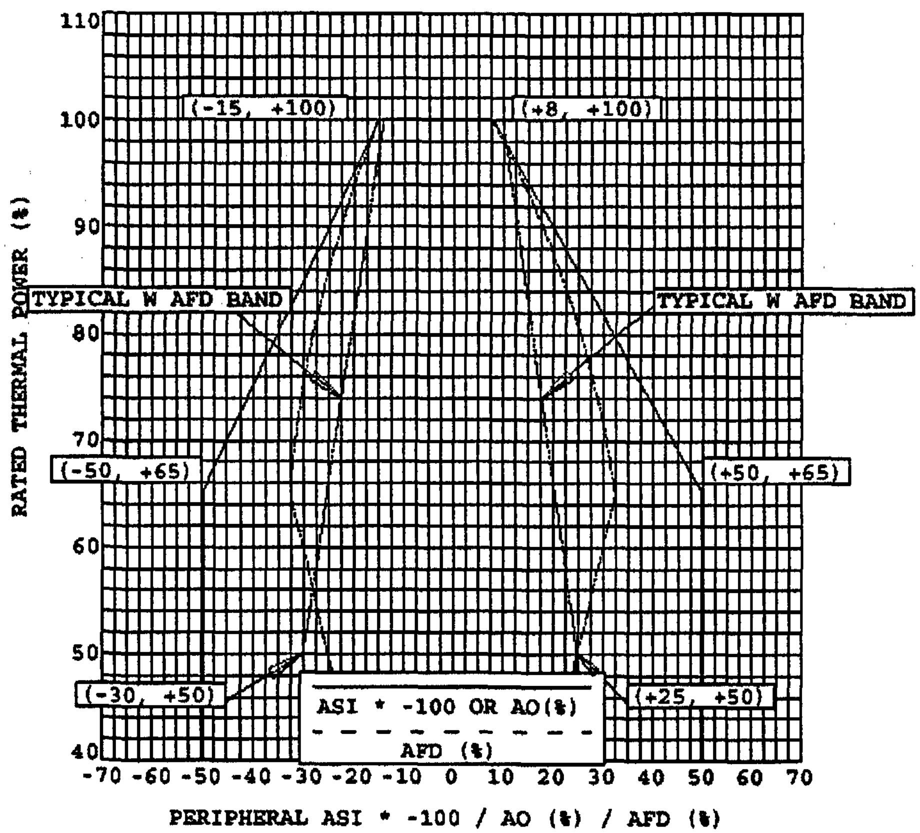
RAOC Condition I

FIGURE 4

ST LUCIE UNIT 2 CYCLE 13
AO and AFD BAND COMPARISON
NO ASI UNCERTAINTY APPLIED



RAOC Condition I

- RAOC EVALUATION (continued)

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RAOC Condition I

FIGURE 1

ST LUCIE UNIT 2 CYCLE 13
AO and AFD BAND COMPARISON
8% ASI UNCERTAINTY APPLIED

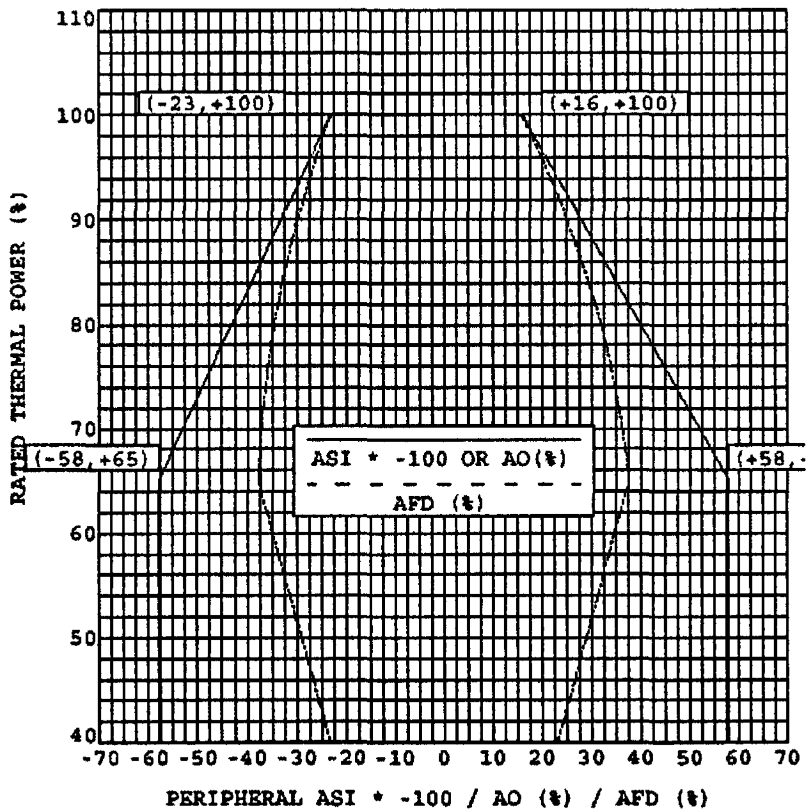
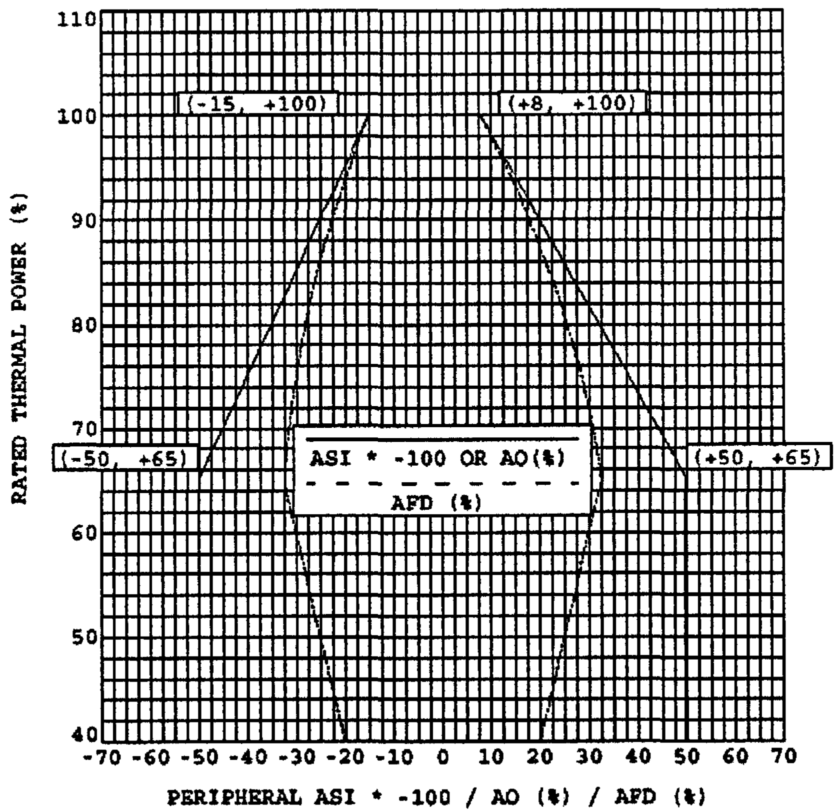


FIGURE 2

ST LUCIE UNIT 2 CYCLE 13
AO and AFD BAND COMPARISON
NO ASI UNCERTAINTY APPLIED



RAOC Condition I

- RAOC EVALUATION (continued)

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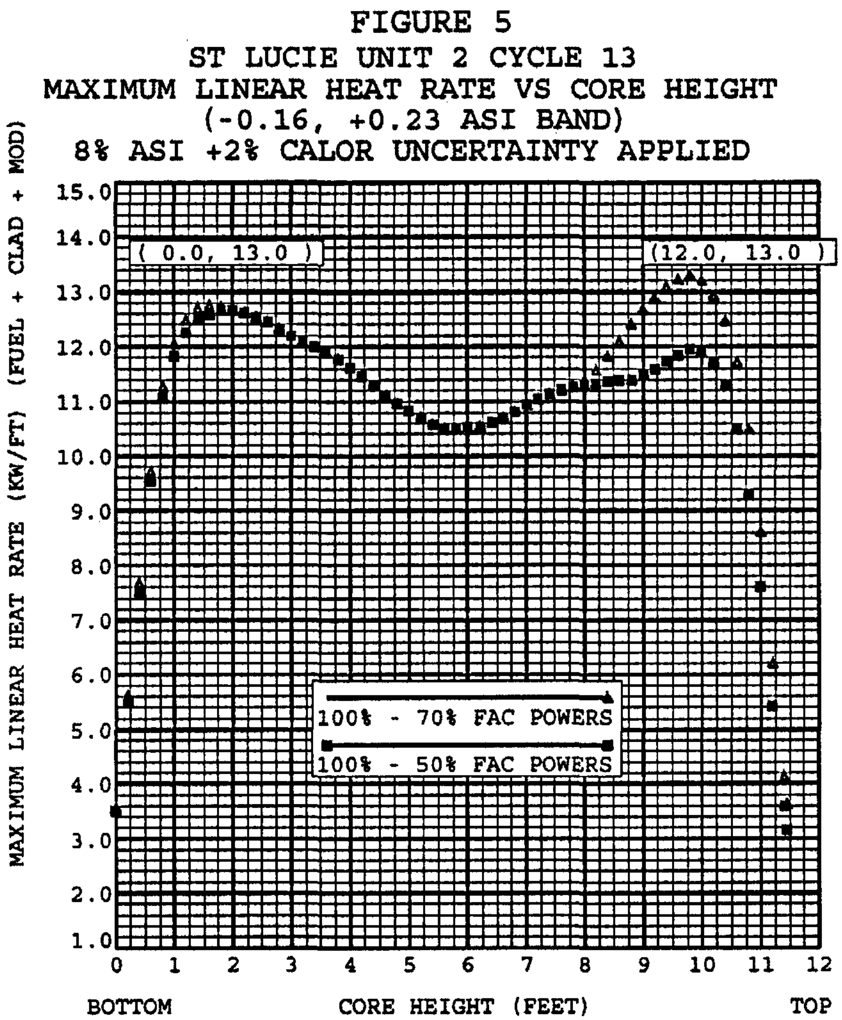
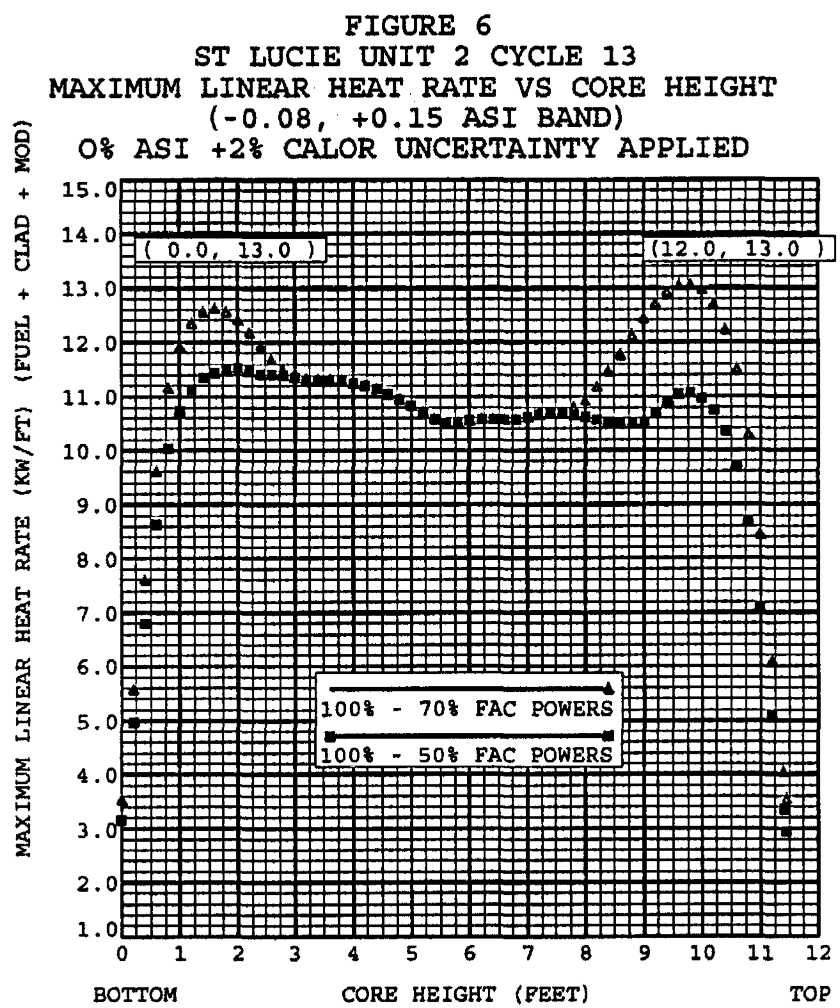
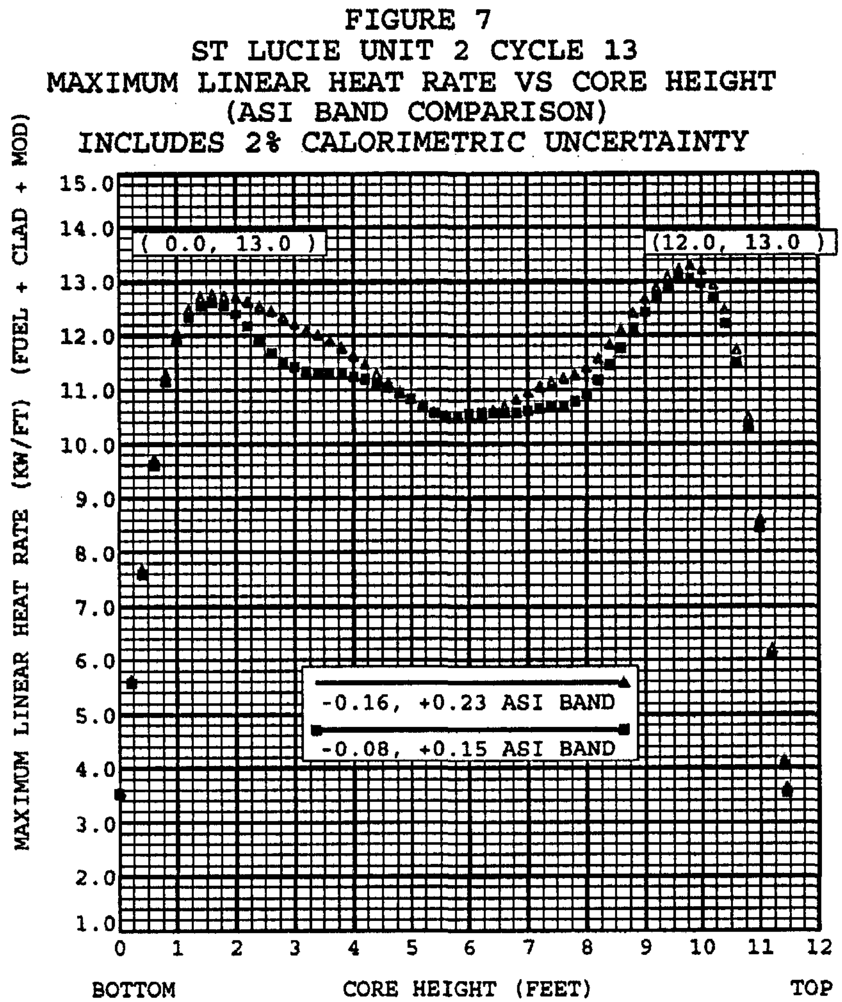
  - Each axial power shape analyzed to determine if the linear heat rate constraints are met

RAOC Condition I





RAOC Condition I



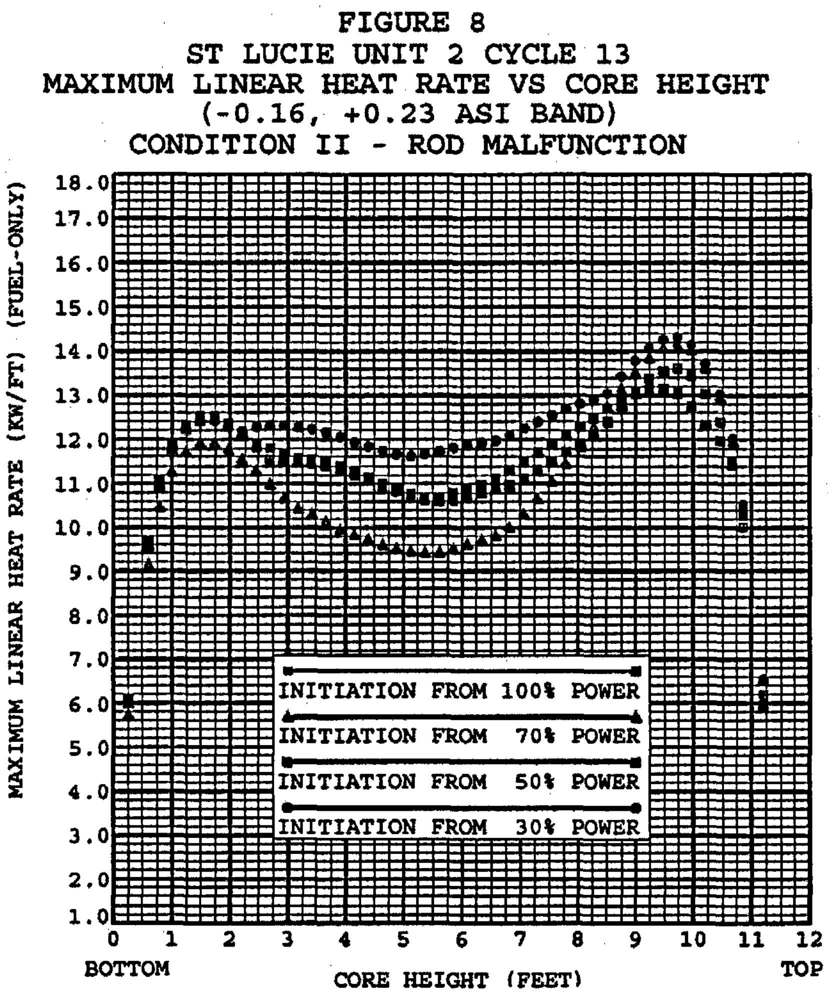
RAOC Condition I

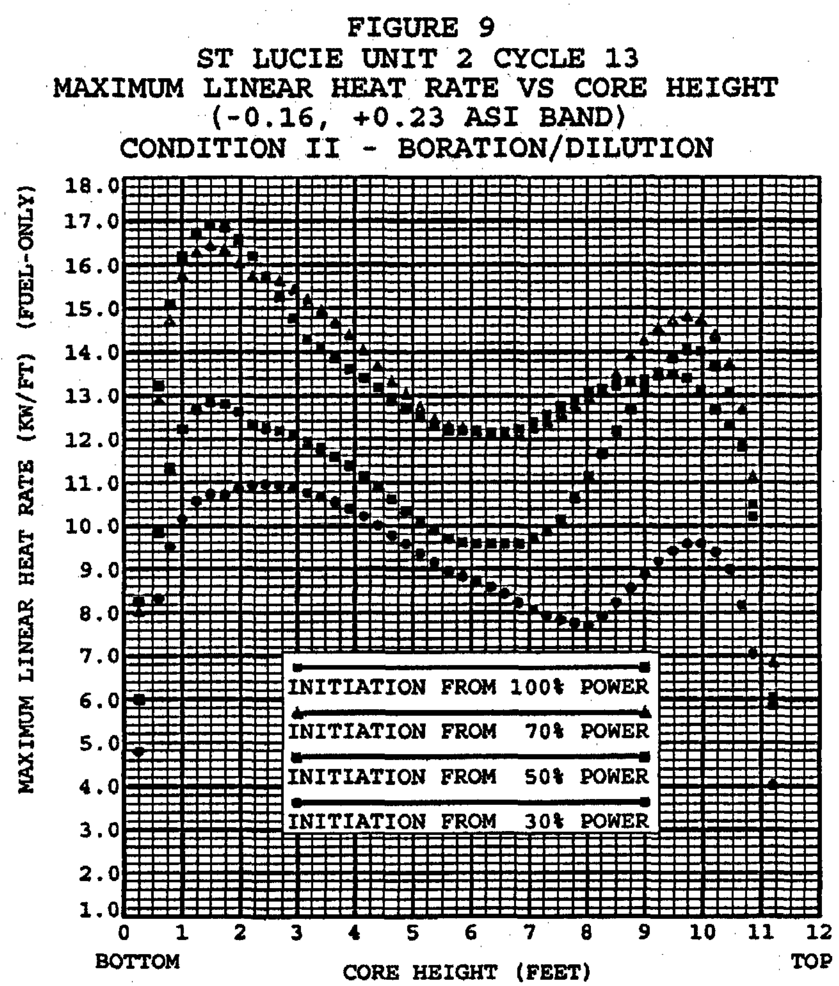
- Conclusions - Condition I RAOC Evaluations
  - Feasibility for implementing RAOC in future cycles for St. Lucie Unit 2 confirmed
  - Results are as expected
  - T/H design has confirmed acceptable DNB results for verification of linear heat rate LCO should the incore detectors become inoperable
  - A change in the Axial Shape Index (ASI) breakpoints from 65% power to 50 % power will be proposed
    - Reduces degree of bowing in AFD space while allowing sufficient degree of operational flexibility

RAOC Condition II

- Standard Westinghouse Condition II accident studies performed
  - Cooldown transients
  - Control rod withdrawal
  - Boration/Dilution
    - Note: Manual rod control only - no automatic rod withdrawal capability in St. Lucie Unit 2

RAOC Condition II





RAOC Condition II

- Conclusions - Condition II RAOC Evaluations
  - Feasibility for implementing RAOC in future cycles for St. Lucie Unit 2 confirmed
  - Results are as expected - Comparisons to sister Turkey Point Units show similar behavior
  - Ample margin exists to limits

Section 6
T/H - Code, Core Limits, Correlation

Outline

- T/H Analysis Approach
- ABB-NV with VIPRE
- St. Lucie 2 VIPRE Model
- Revised Thermal Design Procedure (RTDP)
- Core Thermal Limits for TM/LP Trip
- RAOC Power Shape DNB Verification
- Accident Statepoint Analysis

T/H Analysis Approach

- Utilize NRC-approved bounding evaluation results, not impacted by WCAP-9272, for St. Lucie 2 core and CE-type fuel
  - Engineering hot channel factors
  - Core parameter and peaking factor uncertainties, etc.

- Apply NRC-approved code and method
  - Westinghouse version of VIPRE-01 (VIPRE)
  - Revised Thermal Design Procedure (RTDP)
  - ABB-NV DNB correlation

- Adjustment to existing design process
  - Core thermal limits for TM/LP
  - RAOC power shape verification

CE-ABB DNB Correlation

- CE-ABB DNB correlation (CENPD-387-P-A)
  - ABB-NV for 14x14 & 16x16 non-mixing vane fuels
  - ABB-TV (14x14 Turbo only)

- Qualification with VIPRE submitted to NRC
  - Addendum 1 to WCAP-14565-P-A (June 03)
  - VIPRE equivalent to TORC for DNBR calculations
  - Current 95/95 DNBR limit of 1.13 remains unchanged
  - Current applicable range remains valid

St. Lucie 2 VIPRE Model

- One-pass model (WCAP-14565-P-A)
  - Core & hot channels modeled in one calculation
  - Applicable to CE-type PWR cores
  - Designated hot channels and locations
  - Model considers hydraulic loss due to core plates

- Bounding power and flow distributions

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VIPRE 25-Channel Model (1/8th HA)

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VIRPE 25-Channel Model (1/8th Core)

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Revised Thermal Design Procedure (RTDP)

- RTDP (WCAP-11397-P-A) is similar to current ESCU
  - Statistical DNB design method
  - Applied to most Westinghouse plants including Turkey Point
  - Current uncertainty values remained unchanged

- Uncertainties to be convoluted for 95/95 DNBR limit
  - Core parameters
  - Hot channel factors
  - Engineering manufacturing tolerances
  - DNB correlation, subchannel and transient codes

RTDP Application

- St. Lucie 2 application in compliance with SER conditions
- RTDP DNBR limit verified and applied at DNB limiting conditions
  - Loss of flow & seized rotor (locked rotor)
  - Pre-trip steamline break (HFP SLB)
  - CEA withdrawal at power (rod withdrawal)
  - CEA drop and static rod misalignment, etc.
- RTDP not used
  - Hot zero power steamline break
  - CEA withdrawal from subcritical

Core Thermal Limits for TM/LP Trip

- Input for TM/LP trip setpoint confirmation

- Core Thermal Limits: T-inlet vs. Power
  - DNBR
  - ABB-NV maximum quality
  - Vessel exit boiling
  - At different pressure levels

- ΔT-inlet vs. (-ASI) limit accounts for axial shape effects

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Axial Power Shapes for DNB Analysis

- Reference axial power shape for HFP RTDP events
  - Loss of flow, seized rotor, dropped rod, etc.
  - Based on nominal operating range & conditions (Condition I)
  - Affected by ASI operating limits in Fig. 3.2-4 of COLR

- Accident shapes for TM/LP Trip
  - Reference ΔT-inlet vs. ASI limit
  - Condition II RAOC shapes

- Accident specific power distributions
  - Steamline break
  - HZP events

Accident Statepoint Analysis

- VIPRE transient calculations
  - Model and method consistent with WCAP-14565-P-A
  - Fuel rod model initialized with FATES temperature data

- DNB limiting accidents to be analyzed:
  - Loss of flow
  - Seized rotor
  - Steamline break
  - RCCA malfunction, etc.

Summary

- ABB-NV has been validated with VIPRE
- St. Lucie 2 VIPRE model consistent with WCAP-14565-P-A
- DNBR limit for transient analysis statistically determined using RTDP
- Core limits define DNB basis for TM/LP trip setpoints
- RAOC power shape verification is conducted on cycle-specific basis
- Accident analysis similar to those for other PWR

Section 8
RETRAN Model

RETRAN Code

- No Code Changes Are Required to Support the St. Lucie 2 Model Implementation

St. Lucie 2 RETRAN Model

- Changes made to:
  - Nodalization
  - Control/Protection Systems
- No new code options are implemented in the St. Lucie 2 Model that were not addressed in WCAP-14882-P-A ("RETRAN Modeling and Qualification for Westinghouse Pressurized Water Reactor Non-LOCA Safety Analyses")

St Lucie 2 RETRAN Model

- Although the SER for WCAP-14882 limits the applicability of the WCAP to Westinghouse designed PWRs, many portions of the WCAP are equally applicable to the CE model developed for St. Lucie 2
  - The modeling options described in WCAP-14882 are equally applicable to the St. Lucie 2 model
  - The SER limitations discussion in WCAP-14882 are equally applicable to the St. Lucie 2 model

St Lucie 2 Reactor Coolant System

- The changes made for the CE design for St. Lucie 2 include:

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- Other change made:

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RCS Diagram

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Vessel Diagram

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Steam Generator Diagram

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St. Lucie 2 RETRAN Model Changes

- Control/Protection System Changes compared to WCAP-14882-P-A Model
  - Except for RCS flow measurement, sensors and sensor locations are similar
  - Actions that can be implemented (reactor trip, safety injection, valve opening/closing, etc.) are effectively the same
  - Processing of the sensor protection signals is different
  - Basic control system layout is similar to Westinghouse models

St. Lucie 2 RETRAN Model Changes

- Protection System modeling reflects St. Lucie 2 specific design, including:
  - RCS Flow measurement based upon steam generator delta-P
  - Reactor trip functions
    - Variable High Power
    - Thermal Margin Low Pressure*
    - Start-up Rate
    - Local Power Density*
    - Asymmetric SG Transient
    - Low Flow
    - High Pressurizer Pressure
    - Low SG Level
    - Low SG Pressure
    - Turbine Trip

* User-defined ASI vs Time

St. Lucie 2 Control/Protection Modeling

- High SG Level
  - Shut FW Reg. Valve for Affected SG

- High-High SG Level
  - Turbine Trip
  - Trip FW Pump(s), Close MFW Pump Discharge Valve(s)

St. Lucie 2 Control/Protection Modeling

- CE Unique Reactor Trips
  - Thermal Margin Low Pressure (similar to OTΔT)
  - Variable High Power (automatically reduced for downpower transients)
  - Startup Rate Trip (Decades/minute - similar to PFRT trip)
  - High Local Power Density Trip (ASI dependent)

- Low Steam Pressure
  - Reactor Trip (No SI)
  - MSIV / MFIV Closure (Separate Setpoint)

- Low SG Level
  - Reactor Trip
  - AFW initiation to Affected SG only

St. Lucie 2 Control/Protection Modeling

- Safety Injection
  - Initiates on Low Pressurizer Pressure Only
  - Starts SI System
  - Starts Diesels
  - Limits PZR Heater Capacity

- Low Flow Reactor Trip
  - Based on total of the two SG ΔP signals

Section 9
Steamline Break

Pre-Trip SLB (HFP)

- RETRAN model developed

- Based on available protection systems and expected effects of the transient, the basic range of sensitivities were investigated.
  - Inside and Outside Containment
  - Varying MTC
  - With and without offsite power
  - Break size

- Acceptance criteria
  - Peak linear heat rate
  - DNBR

Pre-Trip SLB - Analysis methods

- The following trip functions are modeled:
  - Variable High Power reactor trip (including excore neutron detector power signal and thermal power calculation)
    - Effects of RPV downcomer density changes on the excore detectors are specifically modeled
  - Low Steam Generator Pressure reactor trip
  - High Containment Pressure reactor trip (Inside Containment breaks); although available, not used

Pre-Trip SLB - Expectations/Conclusions

- Large breaks must satisfy ANS Condition IV acceptance criteria, which allows fuel failure

- All breaks expected to satisfy ANS Condition II acceptance criteria

- Results of sensitivity studies demonstrate that plant specific analyses should analyze:
  - Inside containment
  - Most Negative MTC to produce trips on thermal power ΔT and low steamline pressure
  - Without offsite power
  - Spectrum of break sizes

Pre-Trip SLB - Heat Flux as a function of Break Size and MTC

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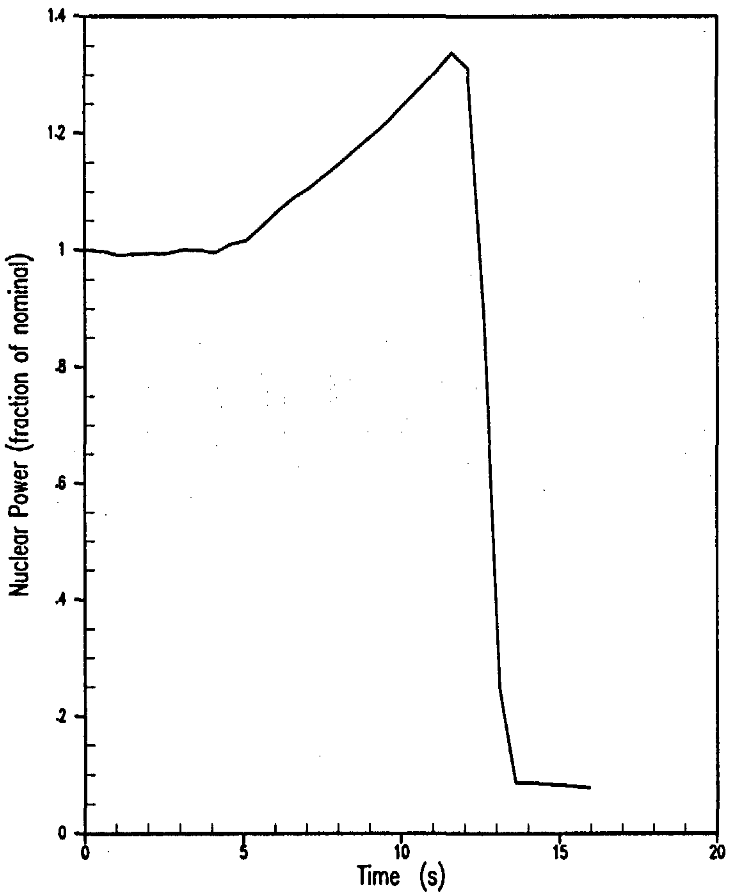
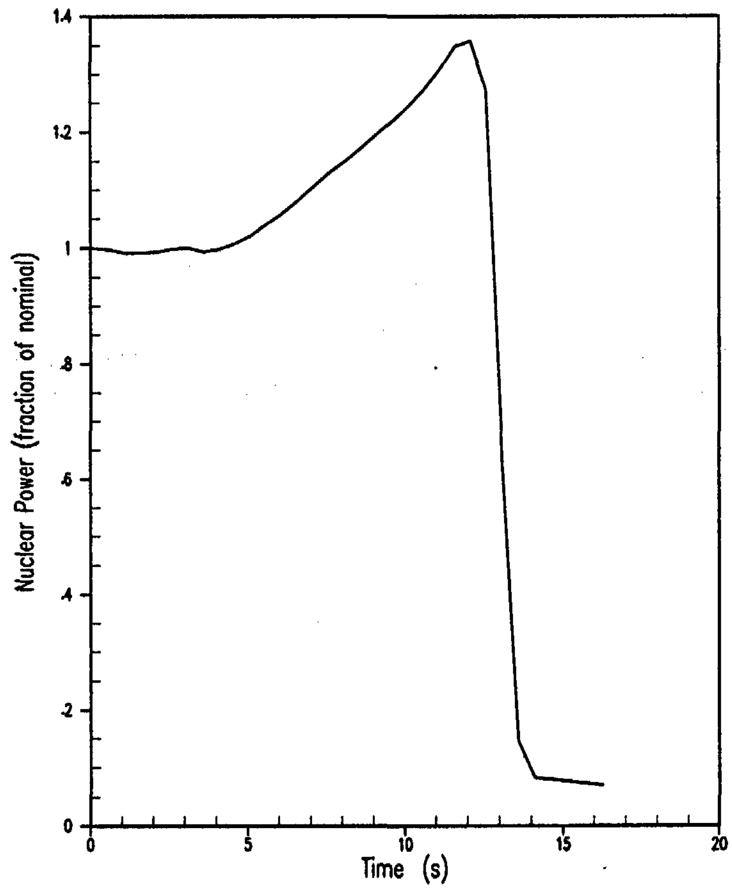
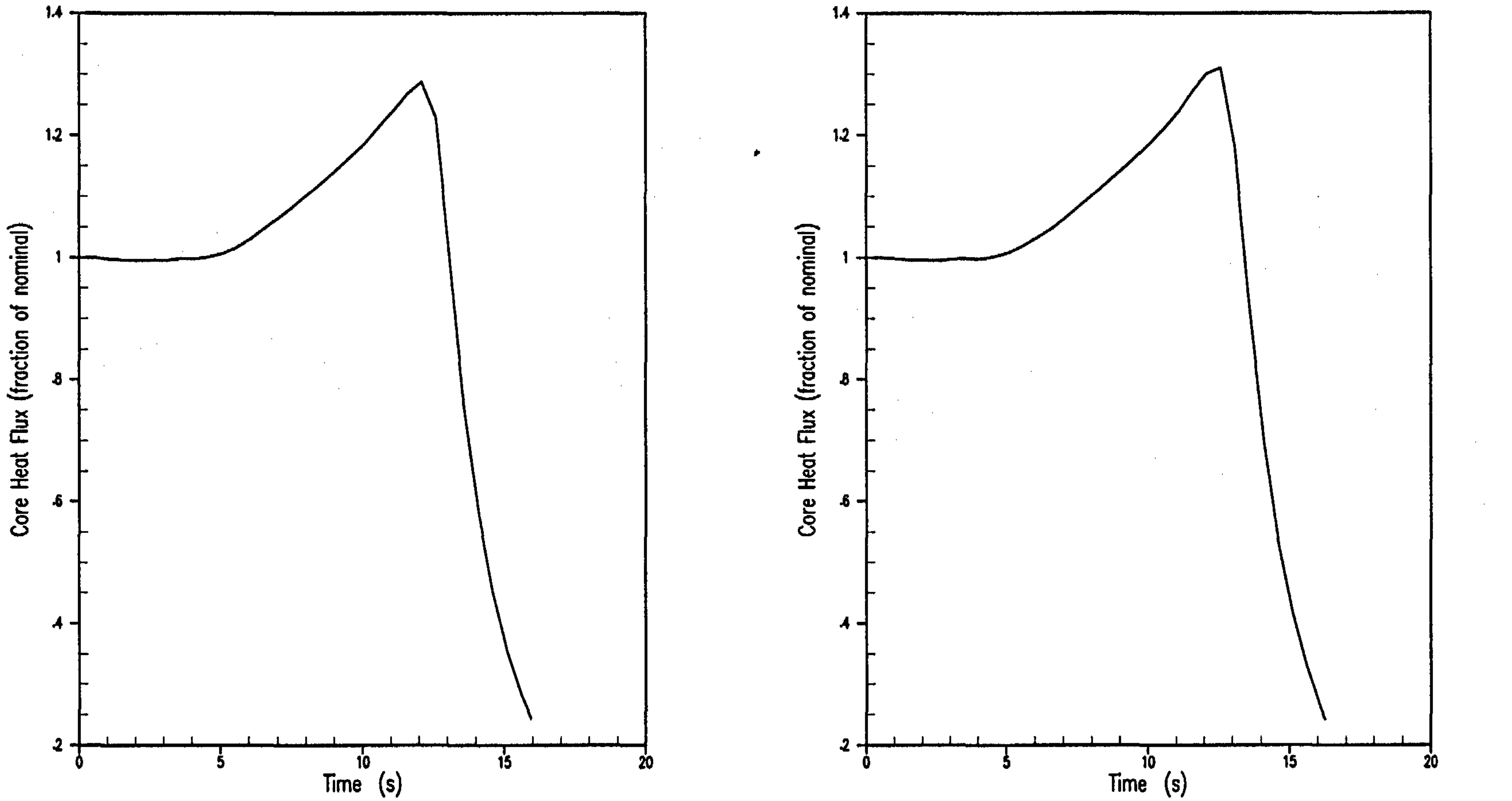
Pre-Trip SLB - Nuclear Power: 2.5 ft^2 break vs 3.2 ft^2 break

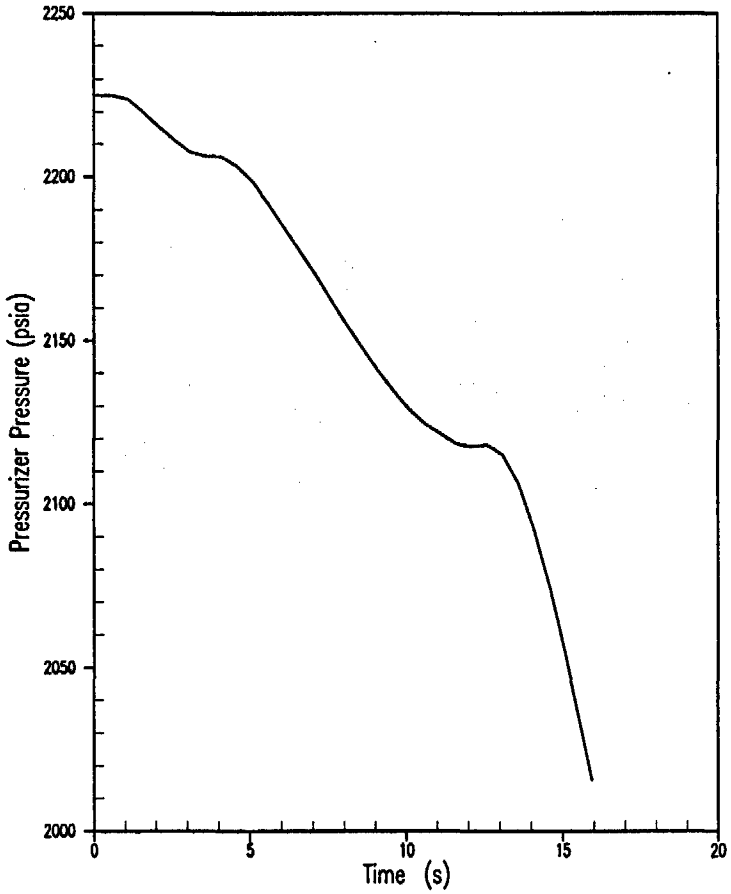


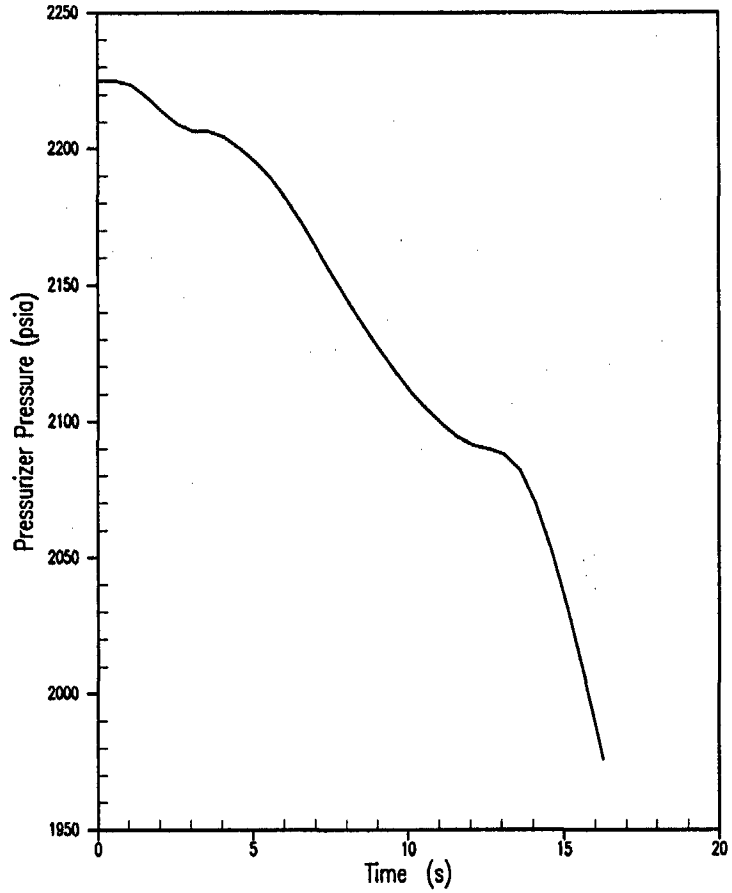


Pre-Trip SLB - Heat Flux: 2.5 ft^2 break vs 3.2 ft^2 break

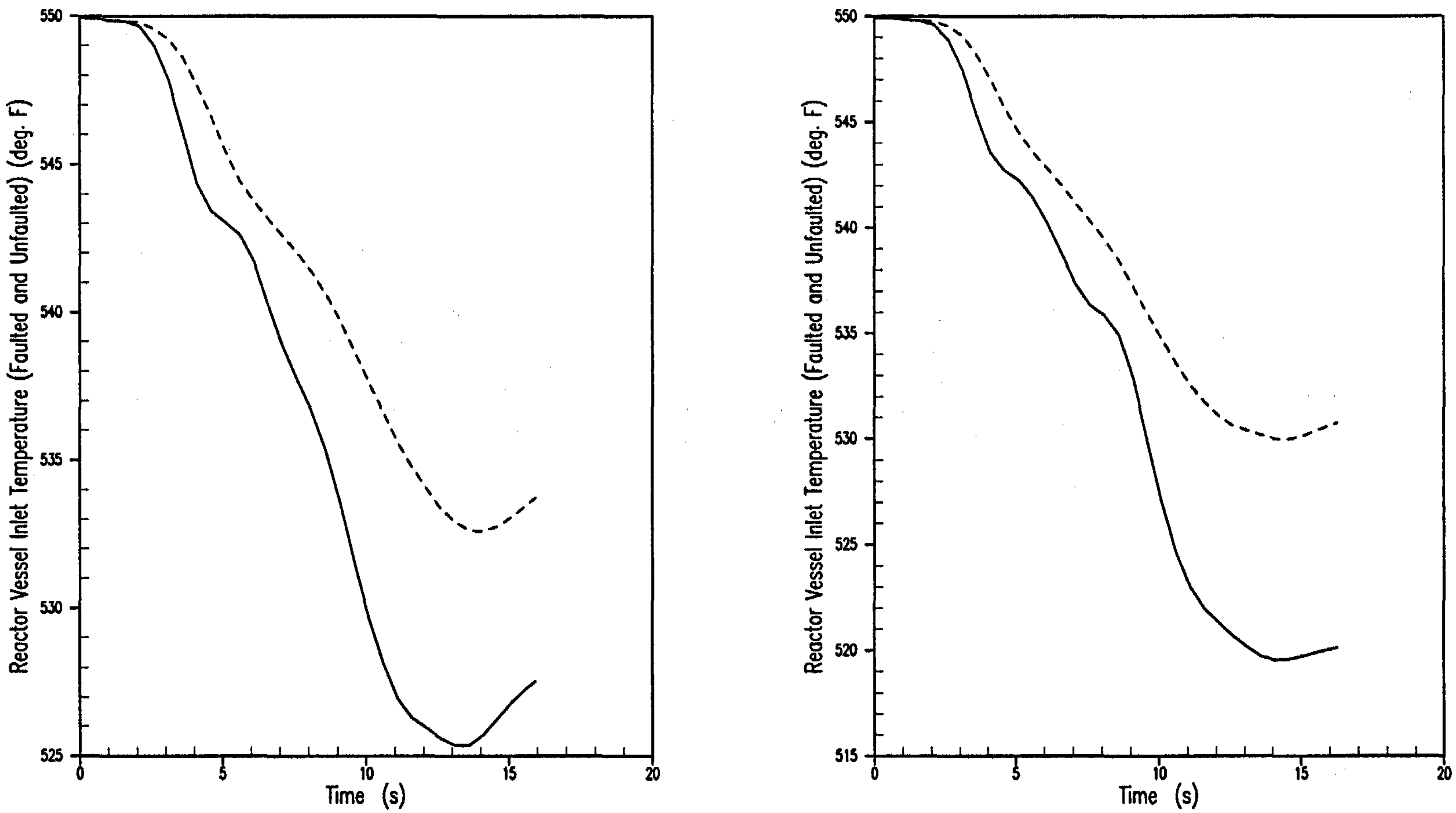


Pre-Trip SLB - Pressurizer Pressure: 2.5 ft^2 vs 3.2 ft^2 break

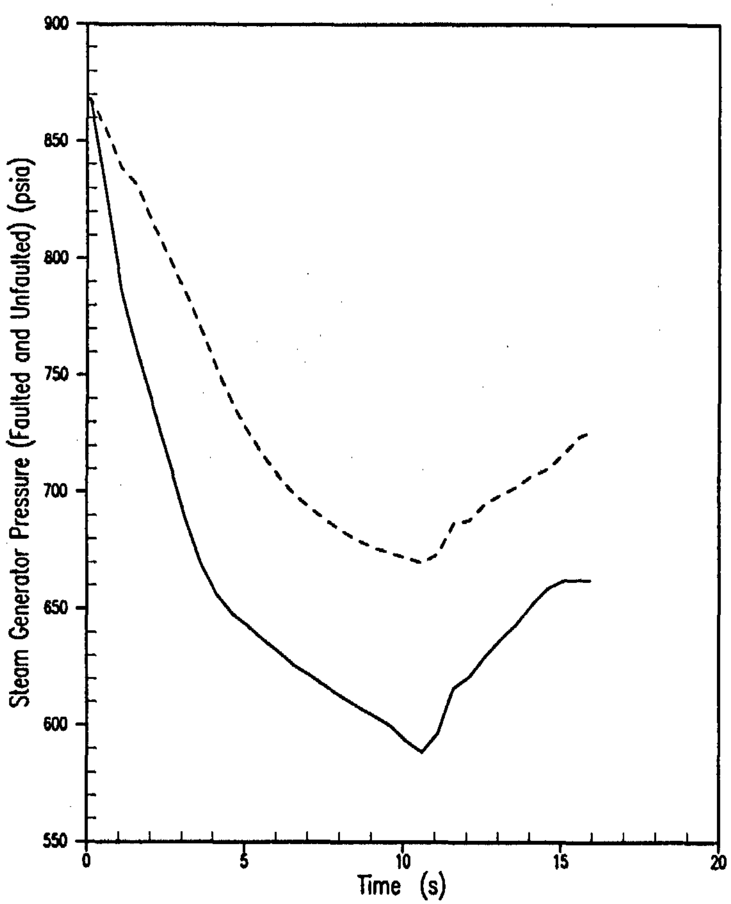


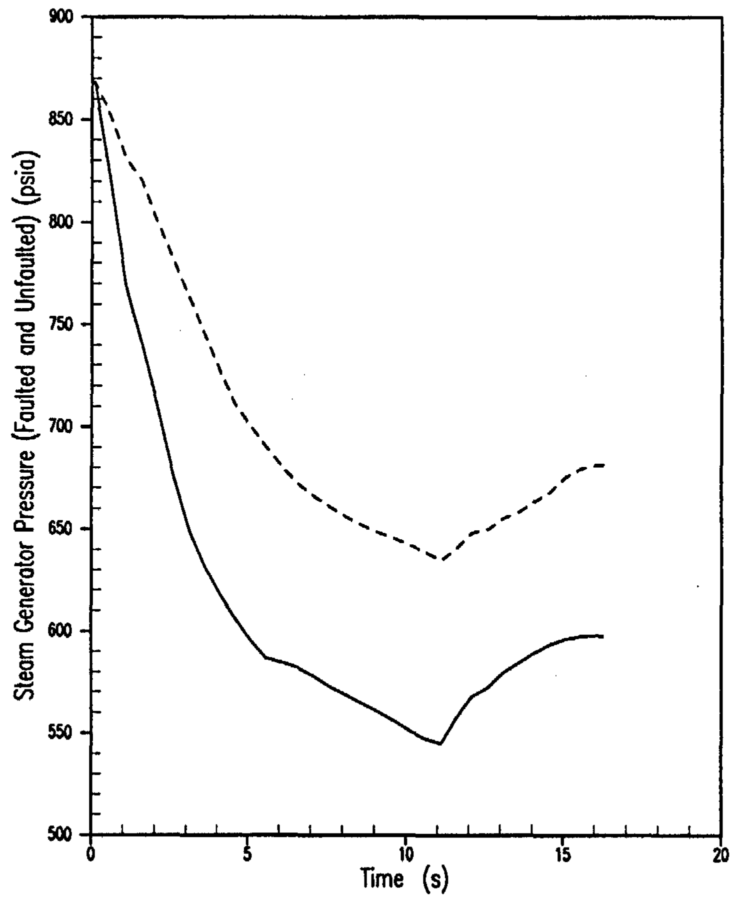


Pre-Trip SLB - Vessel Inlet Temps: 2.5 ft^2 vs 3.2 ft^2 break

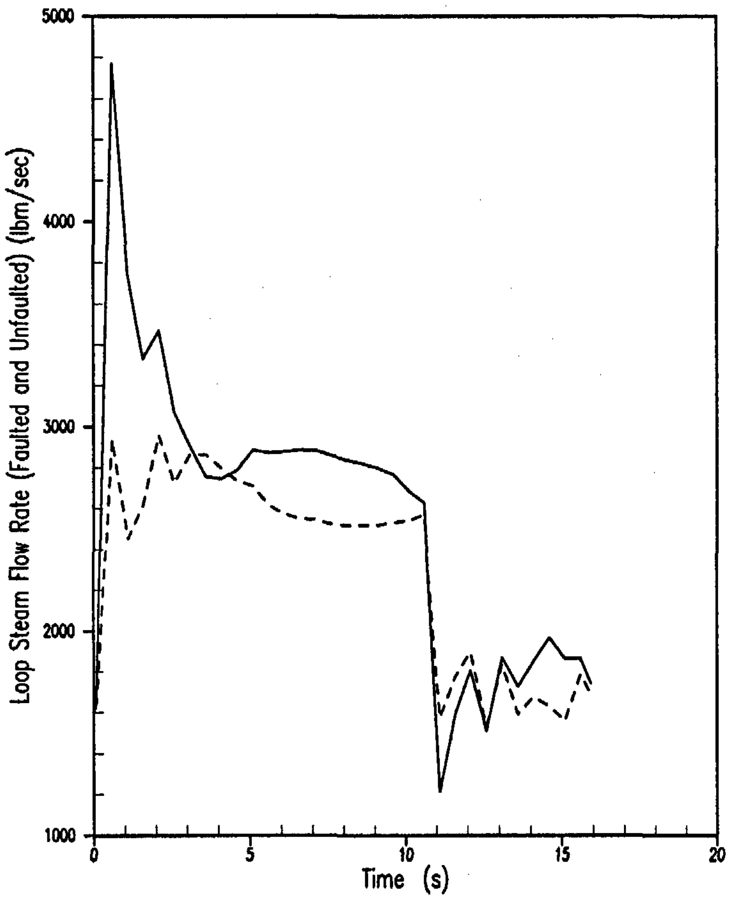


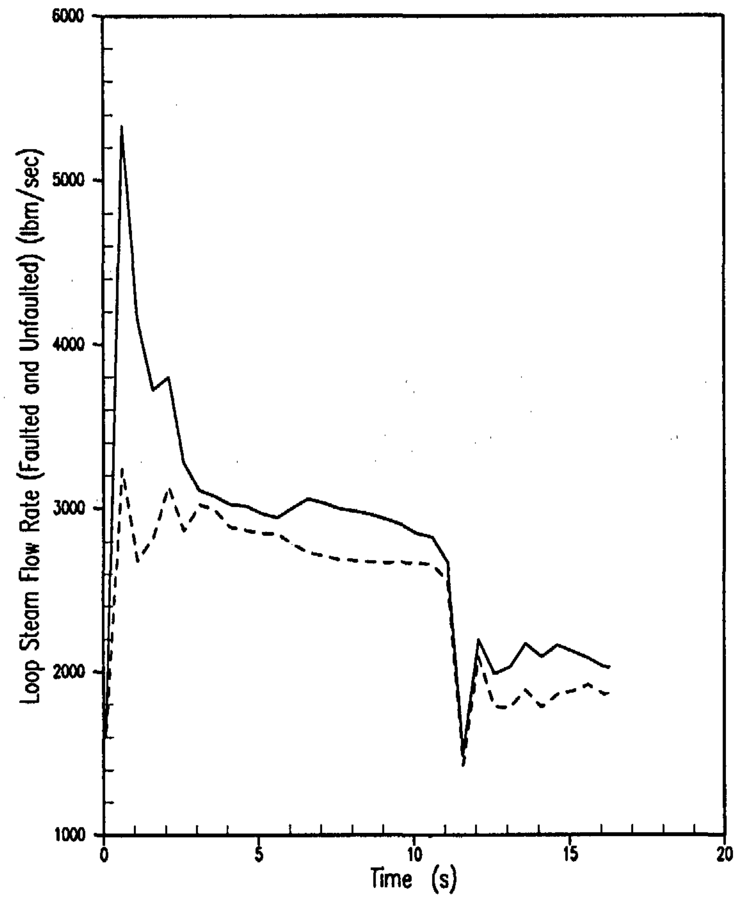
Pre-Trip SLB - SG Pressure: 2.5 ft^2 vs 3.2 ft^2 break



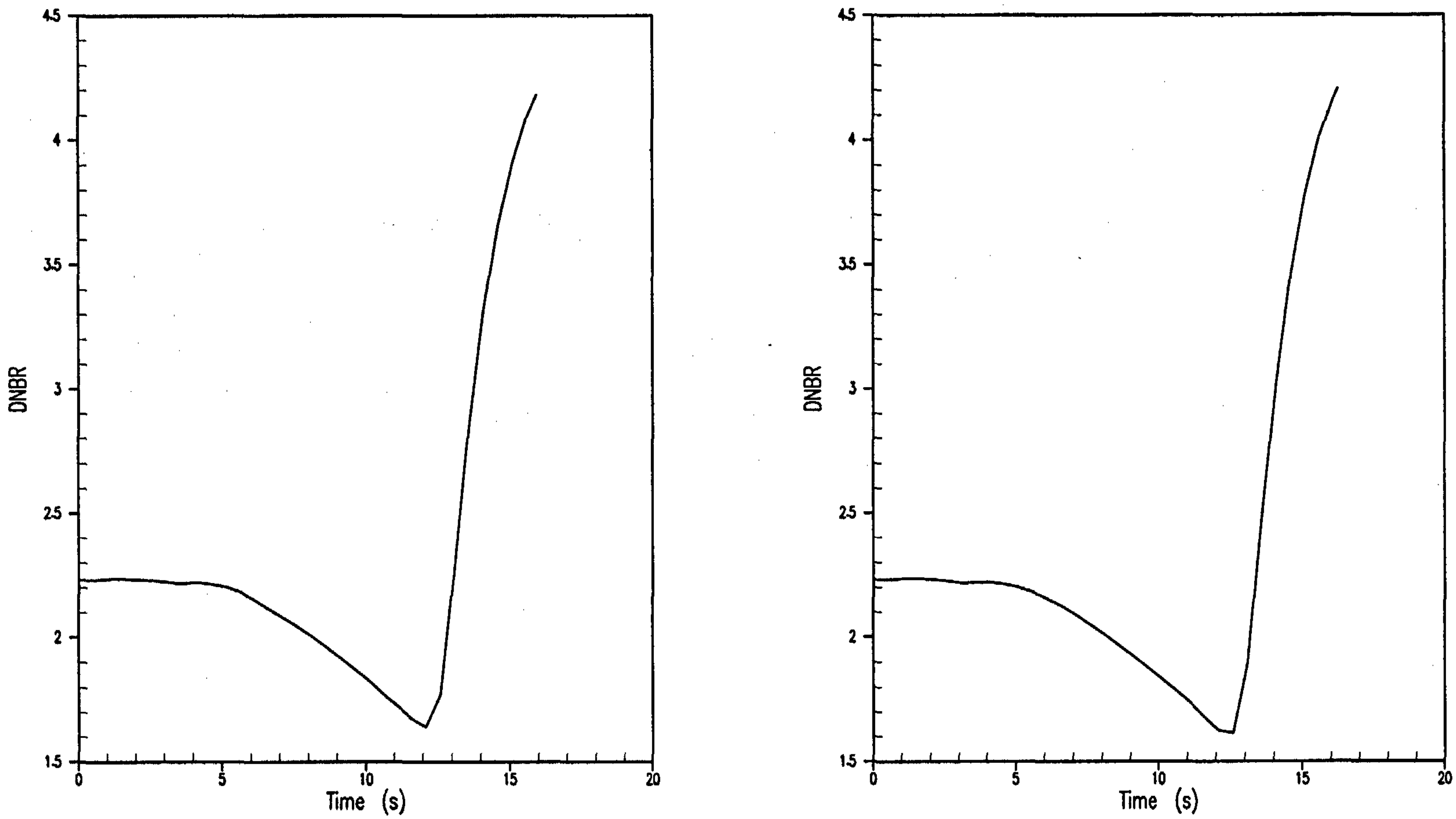


Pre-Trip SLB - SG Loop Steam Flow: 2.5 ft^2 vs 3.2 ft^2 break





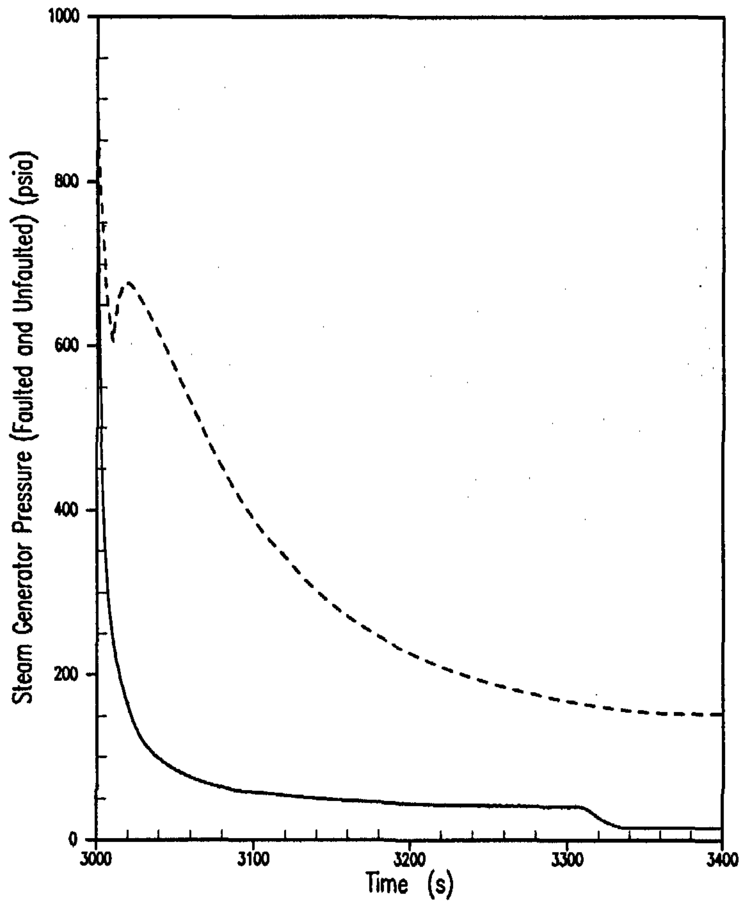
Pre-Trip SLB - DNBR: 2.5 ft^2 vs 3.2 ft^2 break



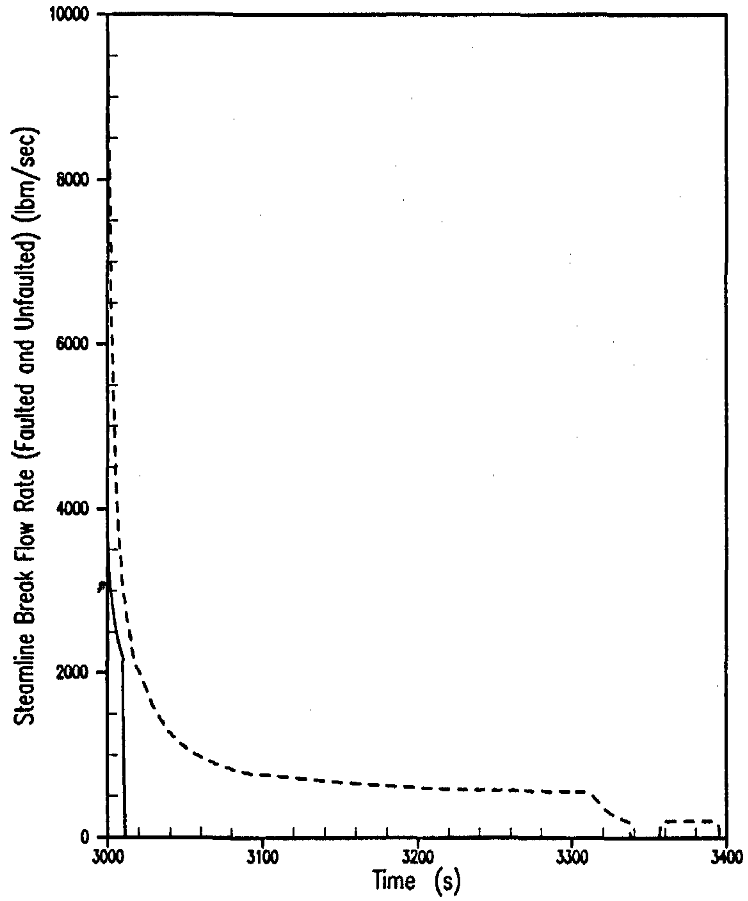
Post-Trip SLB (HZP)

- Transient is very similar to typical Westinghouse transient, except that LSP does not invoke a Safety Injection (use LPP instead)
- Analysis assumes offsite power available
  - Low flow case (without offsite power) has historically been non-limiting with respect to the SLB case with offsite power available based on WCAP-9226-P-A, Rev 1. CE plant design does not present any unique characteristics that would prevent similar behavior
  - Confirmed through developmental analysis for St. Lucie
- Iterative process with Core Design to achieve conservative reactivity swing
- The analysis will demonstrate that the DNB design basis is satisfied

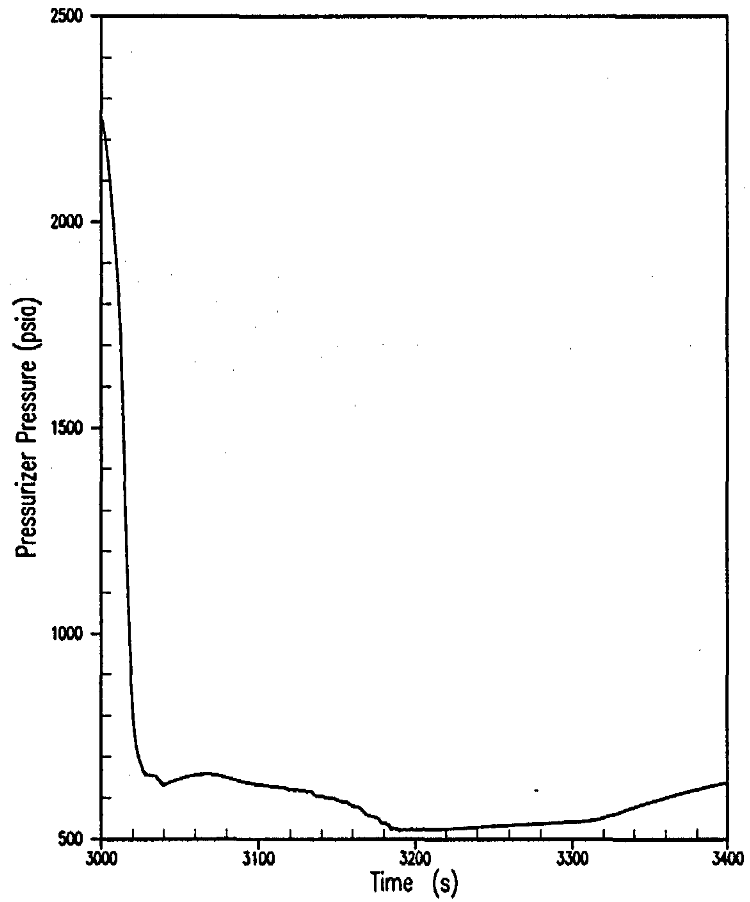
Post-Trip SLB (HZP Trip): SG Pressure



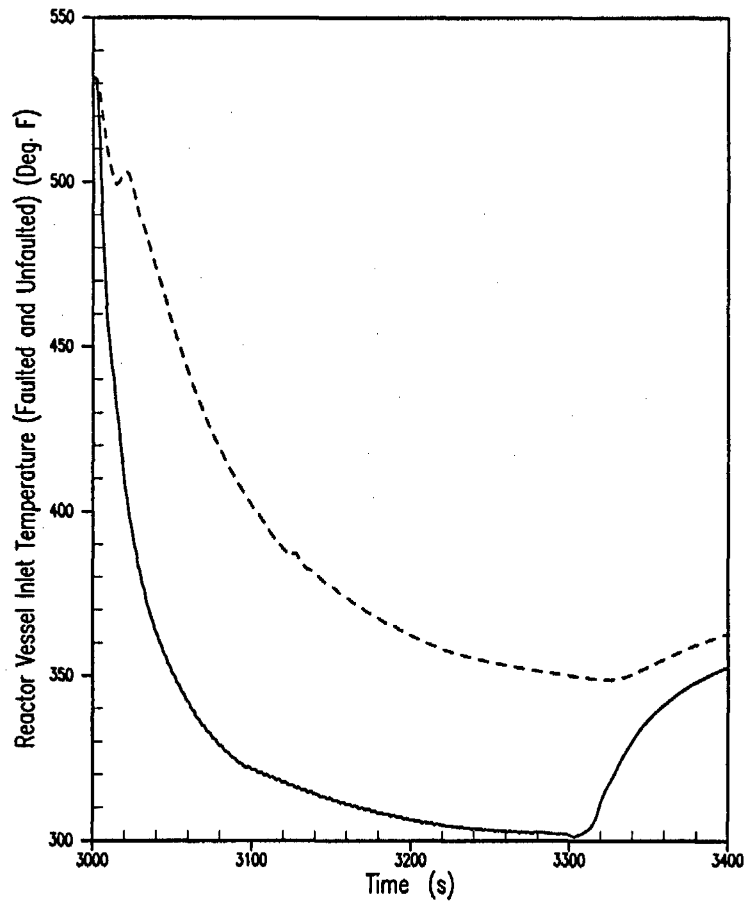
Post-Trip SLB (HZP Trip): Steamline Break Flow



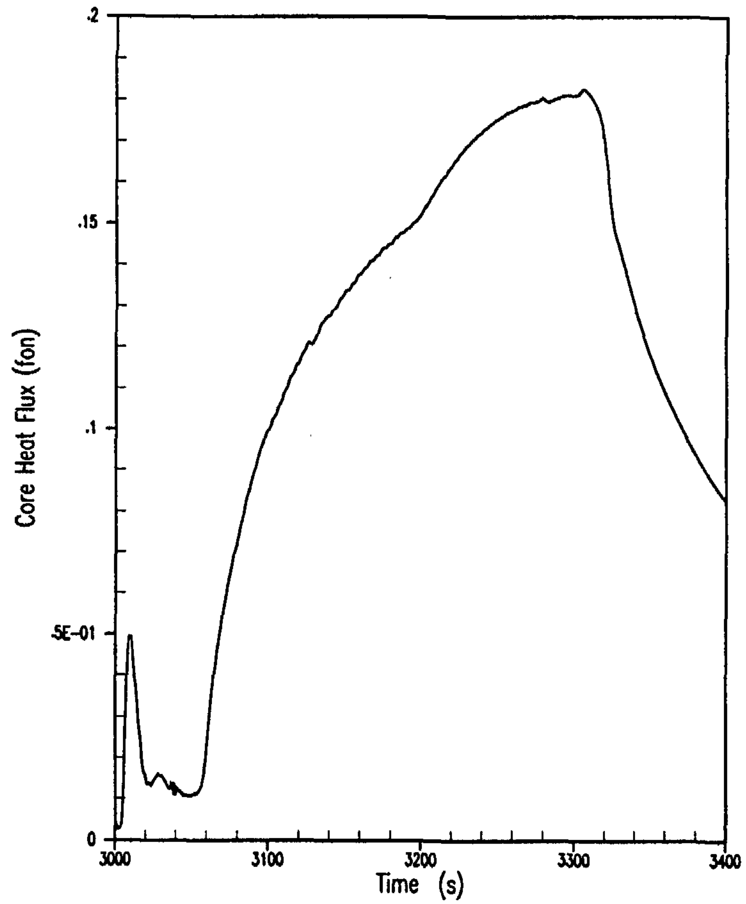
Post-Trip SLB (HZP Trip): Pressurizer Pressure



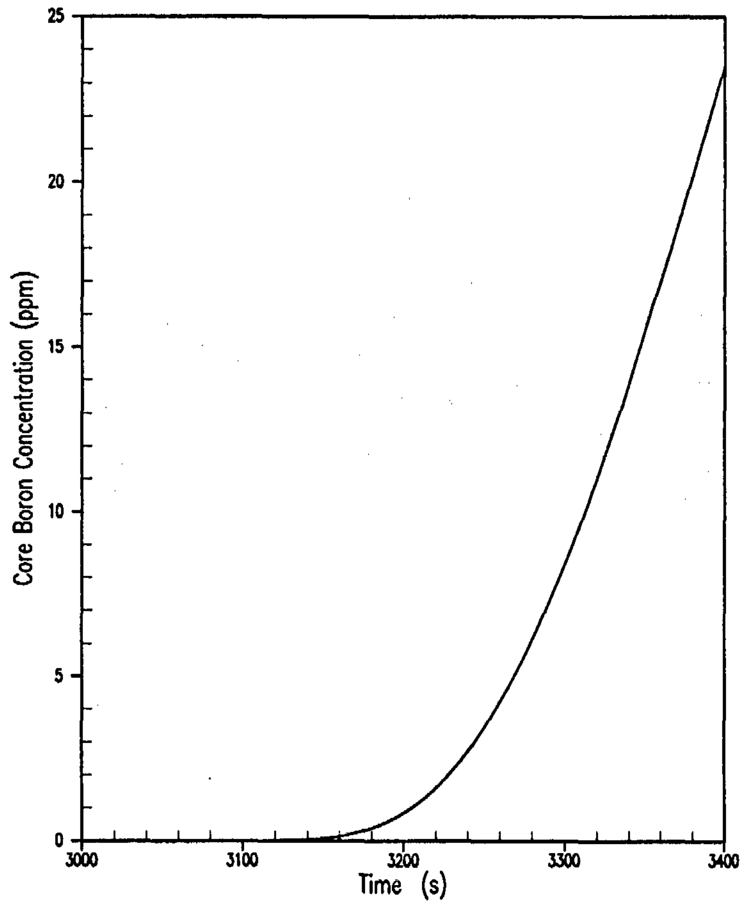
Post-Trip SLB (HZP Trip): Vessel Inlet Temperatures



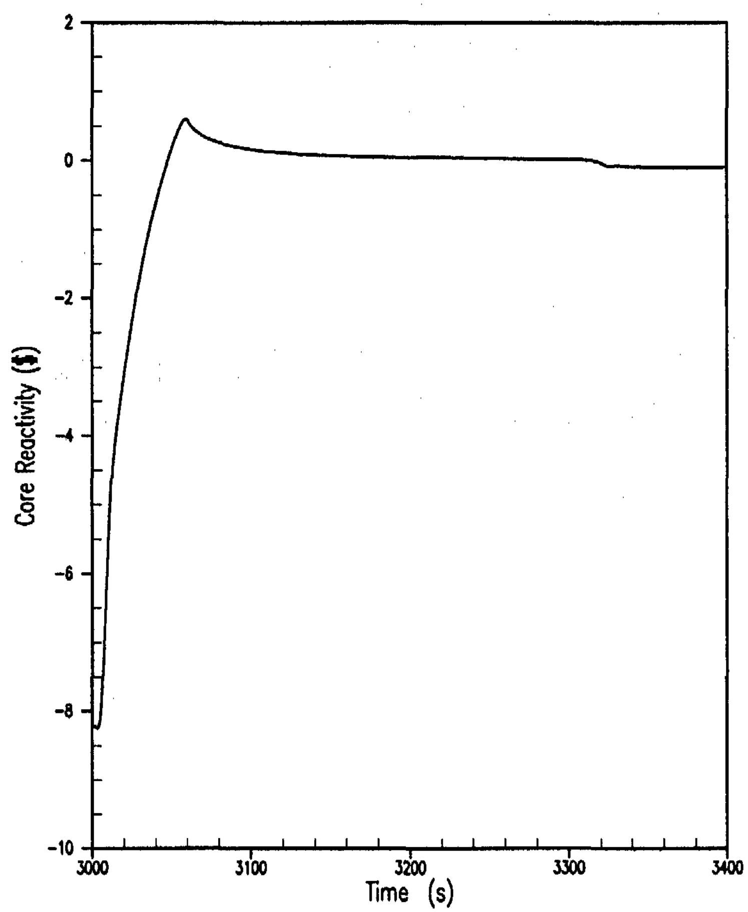
Post-Trip SLB (HZP Trip): Heat Flux



Post-Trip SLB (HZP Trip): Core Boron



Post-Trip SLB (HZP Trip): Core Reactivity



Section 9a
Post Trip Steamline Break Analysis
(Hot Zero Power with Loss of Offsite Power)

Introduction

- Case without (w/o) offsite power is characterized with low RCS flow
  - Core power driven natural circulation
  - Requires detailed crossflow calculation in reactor core
- WCAP-9226-P-A, Rev. 1 conclusion re-validated for St. Lucie 2
  - Case with offsite power bounds case w/o offsite power
  - No change to analysis approach or method

Validation Process

- Accident statepoints from RETRAN
  - For both cases with or w/o offsite power
  - Loop temperatures and flows, pressure, core boron, power vs. time

- Power distributions from SPNOVA/VIPRE
  - At DNB limiting time step
  - Additional reactivity check with RETRAN at other time steps

- DNBR calculation using VIPRE
  - Subchannel model
  - W-3 and McBeth DNB correlations for low flow/low pressure

SPNOVA/VIPRE Coupling

- SPNOVA/VIPRE coupling described in WCAP-15806 (SER issued in 07/03)
  - Executed in either steady state or kinetic mode
  - SPNOVA static neutronic solution consistent with ANC
  - Same nodes between SPNOVA and VIPRE
  - Auxiliary program ANCKVIPRE coordinates data transfer

- Data interface similar to previous calculations for WCAP-9226
  - 3-D core power distribution from SPNOVA to VIPRE
  - Coolant density and temperature from VIPRE to SPNOVA
  - VIPRE fluid solution accounts for cross flow effects

Validation Results

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- Results and conclusions consistent with WCAP-9226-P-A, Rev. 1
- McBeth DNB correlation also shows similar conclusion

Section 10
Asymmetric Steam Generator Transient

ASGT

- ASGT is an event that causes a rapid imbalance in heat transfer between the two SGs
- Initiated by one of the following:
  - single MSIV closure
  - feedwater flow reduction to one SG
  - excessive feedwater flow increase to one SG
- The rapid rate of closure of an MSIV results in the most rapid temperature tilt across the reactor core

ASGT

- ASGT is classified as an ANS Condition II event
- ASGT event is primarily analyzed to ensure that the DNBR Specified Acceptable Fuel Design Limit (SAFDL) is satisfied
- Reactor protection provided by High Steam Generator secondary pressure ΔP reactor trip (functionally a part of the TM/LP trip)

ASGT

- Since ASGT is being analyzed with respect to the DNB related acceptance criteria, the analysis will be treated as a typical Westinghouse Revised Thermal Design Procedure (RTDP) analysis
  - Measurement uncertainties are incorporated in the DNB correlation

- Parametric studies on SG tube plugging level have been performed

Section 11
Feedline Break

Feedline Break

- Typical Analysis methodology for Westinghouse plants provides FSAR Chapter 15 documentation on the long term heat removal capability of the AFW System
  - Cases performed both with, and without, offsite power
  - Overpressurization bounded by Turbine Trip (Condition II) event
  - Fuel failure/dose bounded by SLB (for FLB)

- Current St. Lucie Unit 2 analysis methodology analyzes for overpressurization, fuel failure, and dose
  - Long term heat removal addressed in FSAR Chapter 10
  - Feedline break is a limiting overpressure event due to methodology applied

Feedline Break

- Analysis Methodology to be implemented:
  - Leave the St. Lucie Unit 2 Chapter 10 analysis methodology intact/unchanged
  - Use Westinghouse Chapter 15 arguments as to bounding events for fuel failure/dose
  - Address overpressurization for FLB through analysis with typical Westinghouse assumptions
    - Assume the feedring does not fall on the tube sheet

Section 12
Documentation Expectations

Documentation Expectations

- Submittal
  - Typical licensing submittal format
    - Descriptions of analyses (key assumptions, criteria, codes & methods, etc.)
    - FSAR updates
    - 50.92 for proposed Tech Spec updates

- Schedule
  - January 2004

Production Activities

- Overview & Discussions
- Questions

Westinghouse

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