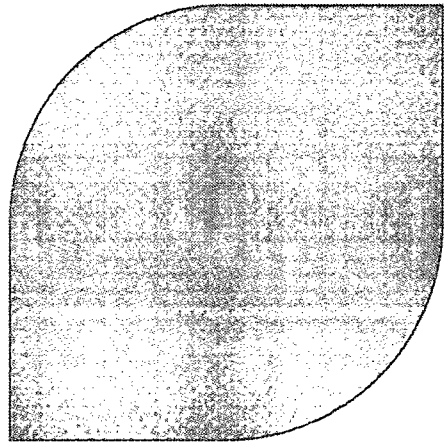


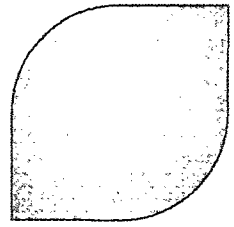
AREVA Safety Limit MCPR Methodology Revision

Michael Garrett
BWR Project Manager
Thermal Hydraulics – Richland

Rockville Maryland – August 12, 2009

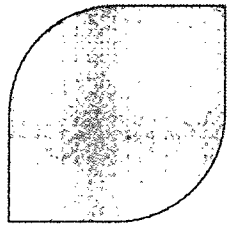
AREVA

Presentation Outline



- Safety Limit MCPR (SLMCPR) Background
- Current SLMCPR Methodology
- Objectives of Revised SLMCPR Methodology
- SLMCPR Methodology Overview
- New Features
- Methodology Assessments
- Schedule

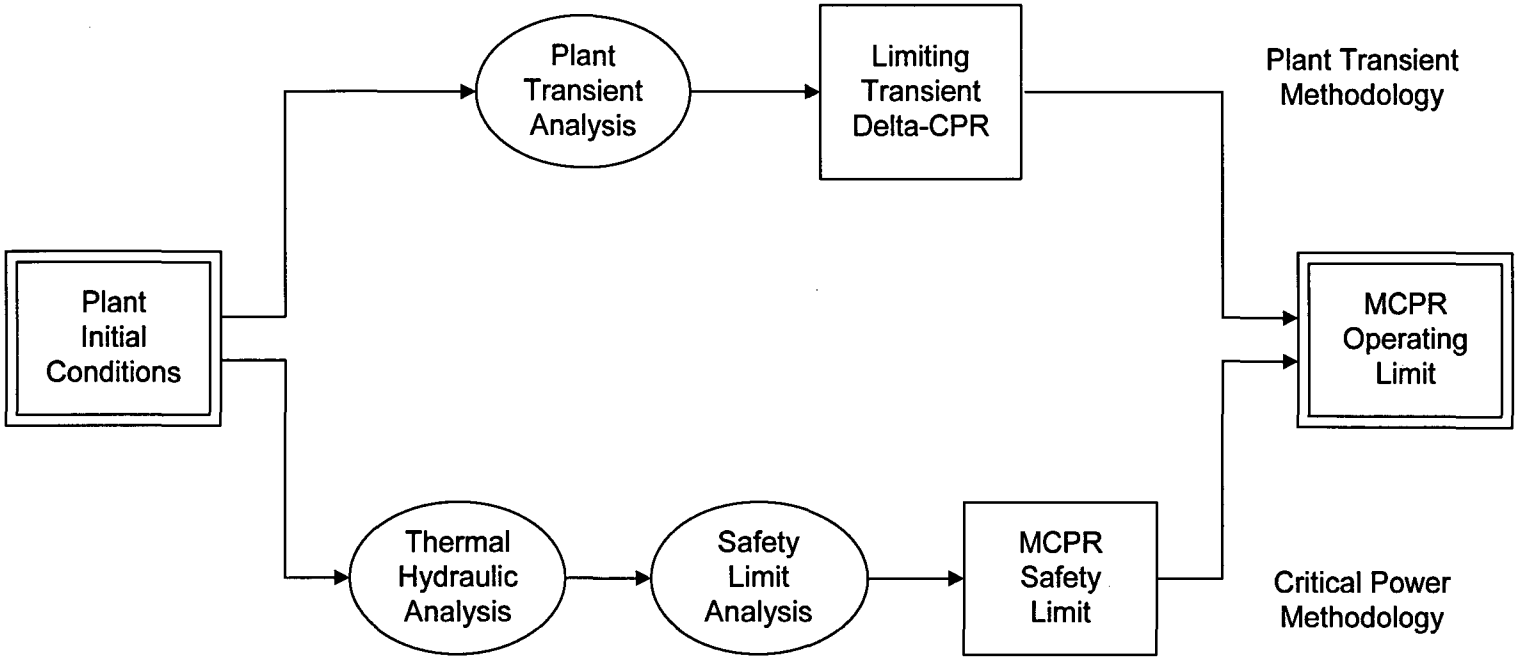
BWR Safety Limit MCPR



- The purpose of the safety limit MCPR (SLMCPR) is to protect the core from boiling transition (BT) during both normal operation and anticipated operational occurrences (transients)
- At least 99.9% of the rods in the core are expected to avoid BT when the minimum CPR during the transient is greater than the SLMCPR
- The SLMCPR is determined by a statistical convolution of uncertainties associated with the calculation of MCPR

BWR Safety Limit MCPR

MCPR Limit Methodology



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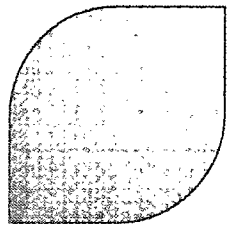
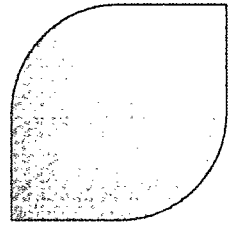
Current SLMCPR Methodology



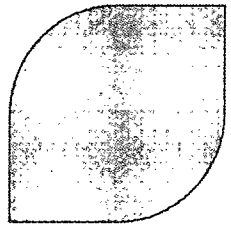
- NRC-Approved Topical Report
  - ANF-524PA Revision 2 and Supplements 1 and 2, *ANF Critical Power Methodology for Boiling Water Reactors,* Advanced Nuclear Fuels Corporation, November 1990
- Topical report describes the calculation process and identifies the system measurement and calculation uncertainties used to determine the SLMCPR
- Cycle specific application of approved methodology is controlled by
  - Implementing analysis guidelines with application instructions for engineers
  - Developing automation codes to perform data manipulation between codes

Current SLMCPR Methodology



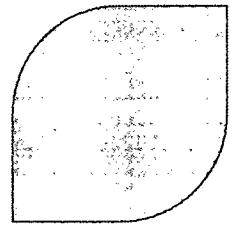
- Methodology supports use of several NRC-approved critical power correlations, including the recently approved ACE correlation
- Implementation of ACE in SLMCPR methodology is described in the NRC-approved topical report for the correlation
  - ANP-10249PA Revision 0, *ACE/ATRIUM10 Critical Power Correlation,* AREVA NP, August 2007
- ACE implementation in the current SLMCPR methodology required conservative assumptions

Revised SLMCPR Methodology
Major Objectives



- Improve implementation of the ACE critical power correlation (ANP-10249PA)
- Use realistic fuel channel bow model from the RODEX4 thermal mechanical methodology (BAW-10247PA)
- Expand interface with MICROBURN-B2 neutronic and thermal hydraulic models (EMF-2158PA)

Revised SLMCPR Methodology
Objective - Improve Implementation of ACE



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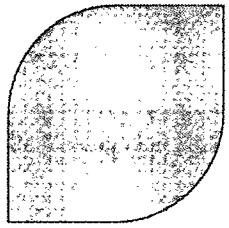
Revised SLMCPR Methodology
Objective - Use Realistic Channel Bow Model



- Current SLMCPR methodology uses a bounding approach to evaluate the impact of fuel channel bow

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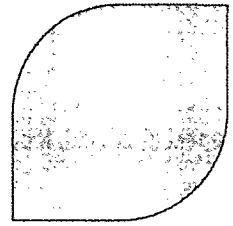
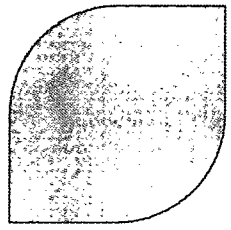
Revised SLMCPR Methodology
Objective - Expand Interface with MICROBURN-B2

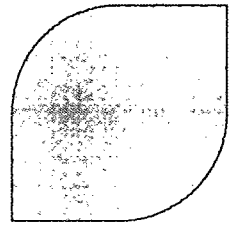


SLMCPR Methodology
(Current and Revised)

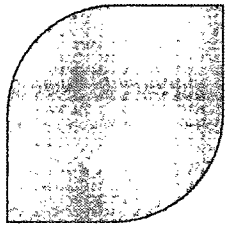


- SLMCPR is determined by a statistical convolution of uncertainties associated with the calculation of MCPR
- Convolution of uncertainties via a Monte Carlo technique
- Consistent with POWERPLEX® CMSS calculation of MCPR
- Appropriate critical power correlation used directly to determine if a rod is in boiling transition
- Explicitly accounts for the effect of channel bow on MCPR
- BT rods for all bundles in the core are summed
- Non-parametric tolerance limits used to determine the number of BT rods with 95% confidence
- SLMCPR analysis is performed each cycle using core and fuel design specific characteristics

SLMCPR Methodology
(Current and Revised)



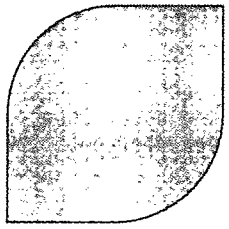
SLMCPR Methodology
(Current and Revised)



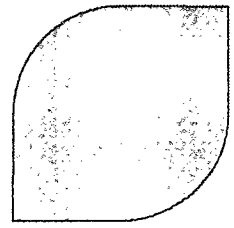
- Rods in BT is determined using a Monte Carlo analysis
- Monte Carlo analysis is a statistical process to determine the distribution function of a parameter that is a function of random variables
- Each random variable is characterized by a mean, standard deviation, and distribution function
- A random value for each input variable is selected
- The parameter of interest is calculated using the random values for the input variables
- The process is repeated a large number of times to create a probability distribution for the parameter of interest

Monte Carlo Trial
(Revised Methodology)

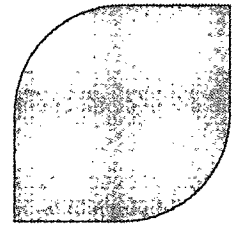
Major Computer Codes
(Revised Methodology)



Major Computer Codes
(Revised Methodology)

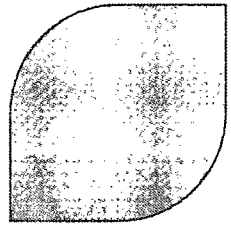


Comparison of Major Features

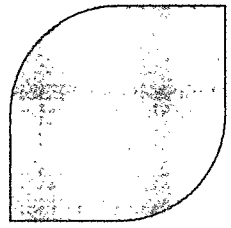


New Features
Core Power Distribution from MICROBURN-B2

New Features
Nominal Channel Bow Assessment



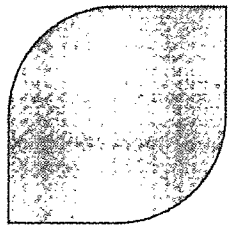
New Features
Channel Bow Uncertainty Assessment



New Features
Channel Bow Uncertainty Assessment (continued)

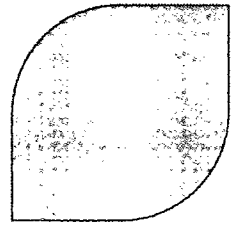
New Features
Assembly Conditions from MICROBURN-B2

Methodology Assessments
Monte Carlo Calculation



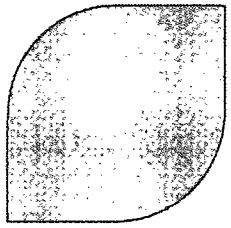
- **Purpose**
  - **Assess SAFLIM3D Monte Carlo coding relative to SAFLIM2**
  - **Assess effect of using MICROBURN-B2 assembly specific axial power shapes and flows**
- **Approach**
  - **Analyze same state point (exposure, operating conditions) from cycle**
  - **Use SAFLIM2 channel bow model results in SAFLIM3D calculation**
    - Fuel rod local peaking from SAFLIM2/CASMO4
    - Channel bow uncertainty from SAFLIM2/SLPREP/CASMO4
    - No 3D nodal power uncertainty due to bow
  - **Assessments with SPCB and ACE critical power correlations**

Methodology Assessments
Monte Carlo Calculation



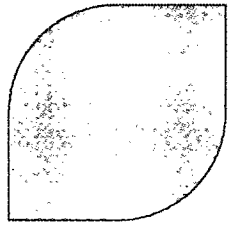
PRELIMINARY – QA REVIEW NOT COMPLETE

Methodology Assessments
Channel Bow Impact



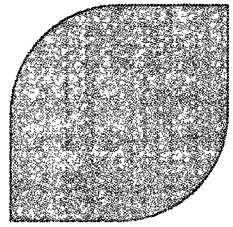
- **Purpose**
  - **Assess channel bow impact with both methodologies**
  - **Assess impact for different CPR correlations and lattice types**
- **Approach**
  - **Analyze same state point from cycle (exposure, operating conditions) with both methodologies**
  - **Base cases include channel bow consistent with methodology**
    - SAFLIM2 calculations same as previous assessment
    - SAFLIM3D local peaking and bow uncertainty from AUTOBOW
    - SAFLIM3D calculations include 3D nodal uncertainty due to bow
  - **Sensitivity case performed with no bow power distributions and no power distribution uncertainties due to bow**
  - **Assessments with SPCB and ACE critical power correlations**
    - ACE applied for ATRIUM 10 and ATRIUM 10XM
    - ACE applied for C-lattice and D-lattice

Methodology Assessments
Channel Bow Impact



PRELIMINARY – QA REVIEW NOT COMPLETE

Topical Report Schedule



- Submittal to NRC planned in September 2009
- Post-submittal meeting scheduled as desired by the NRC
- First planned application of revised SLMCPR methodology to support reactor startup in early 2012
  - Methodology approval desired by early 2011

bcc: NRC:09:085
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