Slides for the ABWR Fuel Topicals Pre-Submittal Meeting on February 24, 2010 (Non-Proprietary)

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Pre-Submittal Meeting for Westinghouse BWR Fuel Licensing Topical Reports

Supplement 4 to BISON LTR RPA-90-90-P-A
Fast Transient and ATWS Methodology for Ch 15
POLCA-T Application for AOO Transient Analysis
POLCA-T Application for ATWS Analysis
Control Rod Blades for ABWR

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ABWR Pre-Submittal Meeting Agenda

- Introductions (STP)
- Attendees (STP)
- Desired Outcomes (STP)
- Review Process Overview (STP)
- BWR Code Overview (WEC)
- Topical Report Schedule (WEC)
- Transient Topical Interface Overview (WEC)
- Topical Report Presentations (WEC)
  - LTR 2
  - LTR 3
  - LTR 4a
  - LTR 4b
  - LTR 11

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Introduction

- STP Team Attendees

- Scott Head	STPNOC
- Jim Tomkins	STPNOC
- Aaron Heinrich	STPNOC
- Jeremy King	WEC
- Ryan Lenahan	WEC
- Mike Riggs	WEC
- Kris Cummings	WEC
- Henrik Björke	WEC
- David Palko	WEC
- Håkan Svensson	WEC
- Yonatan Dag	WEC
- Marcus Eriksson	WEC
- Patricia Quaglia	WEC
- Bjorn Rebensdorff	WEC
- Brad Maurer	WEC
- Koichi Kondo	TANE
- Al Gutterman	Morgan-Lewis

Introduction

- Desired Outcomes
  - Provide an update to the NRC on the plans for fuel related topical reports
  - Provide NRC reviewers with an understanding of the scope content of each topical report presented today
  - Discuss RAI process
  - Receive feedback from NRC
    - Topicals presented today
    - Overall process so far

Update to Plan

- Removing LTR 7b, Containment Analysis, from the LTRs required for fuel amendment
  - Not needed for STP 3 & 4 fuel amendment
  - WEC may pursue at a later date
- To be consistent with the NRC review schedule for WCAP-16182 Rev. 1, the desired acceptance date for LTR 11, Control Rod Blades (CRB) has been changed from June 2011 to Aug 2011

RAI Process

- Phone call 2/18/10
- All RAIs will be issued to STPNOC
- Points of contact Tekia Govan (NRC), Jim Tomkins (STP)
- RAIs will be sent to STPNOC as draft to determine if phone call is needed
- Nominal 30 calendar day response time
- NRC will issue RAIs as they are developed by technical staff
- All RAI Responses be from STPNOC

Westinghouse ABWR Code Overview

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Interface Amongst Transient LTRs

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Fast Transients - Analysis Methods

- Westinghouse Fast Transient Methods (Main Methods)
  - BISON - for core average system response calculations in 1-D
  - BISON/SLAVE - for hot channel CPR response calculations in 1-D
  - POLCA-T - System code with 3-D kinetics model based on POLCA7
- Licensing Topical Reports
  - ASEA Atom RPA 90-90-P-A, "BISON - A One-Dimensional Dynamic Analysis Code for Boiling Water Reactors", December 1991.
  - CENPD-292-P-A, "BISON – One-Dimensional Dynamic Analysis Code for Boiling Water Reactors: Supplement 1 to Code Description and Qualification", July 1996.
  - WCAP-16606-P-A, "Supplement 2 to BISON Topical Report RPA 90-90-P-A", January 2008.
  - WCAP -16747-P "POLCA-T: System Analysis Code with Three-Dimensional Core Model", March 2007. Draft SE received for application to CRDA and Stability

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LTR Schedule

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Changes Introduced by ABWR and Full-scope Fuel Related FSAR Applications

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Acronyms & Definitions

Acceptance Criteria	Requirements related to the GDC specified in 10CFR50 Appendix A
AOO	Anticipated Operational Occurrences (i.e. transient events of moderate frequency as stipulated in 1OCFR50 Appendix A.)
ARI	Alternate Control Rod Insertion
Assessment Base	Code Qualification Records (i.e. Validation and Verification)
ATWS	Anticipated Transient Without Scram
CCA	Code Capability Assessment
CPRmin	Minimum transient CPR for the specific transient
CRB	Control Rod Blade
DIVOM	Delta CPR Over Initial MCPR Versus Oscillation Magnitude, a method used to demonstrate protection of the plant MCPR safety limit for anticipated power- and flow oscillations in core

Acronyms & Definitions

DQA	Data Quality Assessment
ECCS	Emergency Core Cooling System
FMCRD	Fine Motion Control Rod Drive
FoM	Figures of Merit - Quantitative standards used to judge the importance of phenomena and assessing code capability. FoM's are derived from the event acceptance criteria.
ICPR	Initial transient CPR for the specific transient
LHGR	Linear Heat Generation Rate
MCPR	Minimum Critical Power Ratio
OLMCPR	Operating Limit Minimum Critical Power Ratio
PCT	Pellet Clad Temperature
PIRT	Phenomena Identification and Ranking Table
RCPB	Reactor Coolant Pressure Boundary
SAFDL	Specified Acceptable Fuel Design Limits
SLCS	Standby Liquid Control System

Acronyms & Definitions

SLMCPR	Safety Limit Minimum CPR
SRP	Standard Review Plan
UNC	OLMCPR uncertainty

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LTR 2
WCAP-17202
Extended Qualification of BISON: Supplement 4 to BISON Topical Report RPA 90-90-P-A

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LTR 2 "Supplement 4 to BISON LTR RPA-90-90-P-A"

- Objective of the Topical Report
  - Removal of SER restrictions
  - Additional qualification of BISON code
- Overview of the Topical Report
  - Removal of SER restrictions
  - New models to extend qualification
- Desired uses and applicability of the Topical Report
  - ABWR and BWR/2-6

Topical Table of Contents

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Removal of SER restrictions

Removal of SER Restriction 2

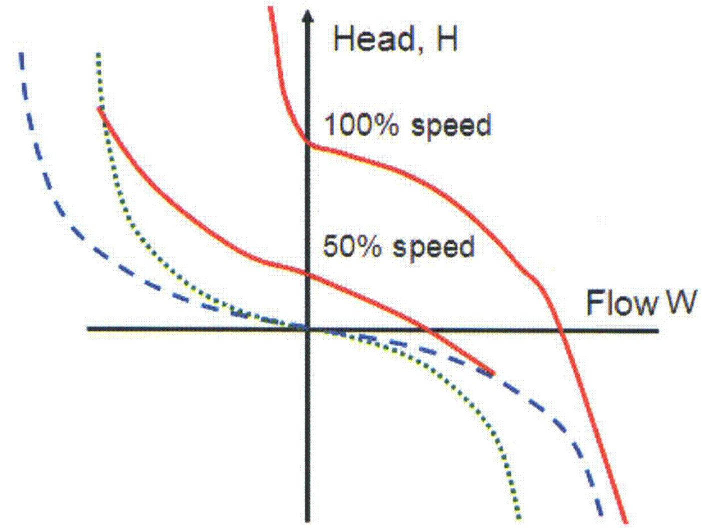
- Removal of SER restriction 2 from BISON LTR RPA-90-90-P-A
- Restriction 2

  "We require justification for use of the recirculation pump model when transients are in other than the first quadrant of the Karman-Knapp diagram"

- Enable BISON to simulate phenomena that could occur in an ABWR

Removal of SER Restriction 2 (cont)

- Description of recirculation pump model
- The model includes the capability to model
  - Running pump
  - Wind-milling pump
  - Stationary pump
- Defined for all possible operational states
- Model validation against experimental data from ABWR Hamaoka 5
  - Reactor internal pump trip
  - Generator load rejection



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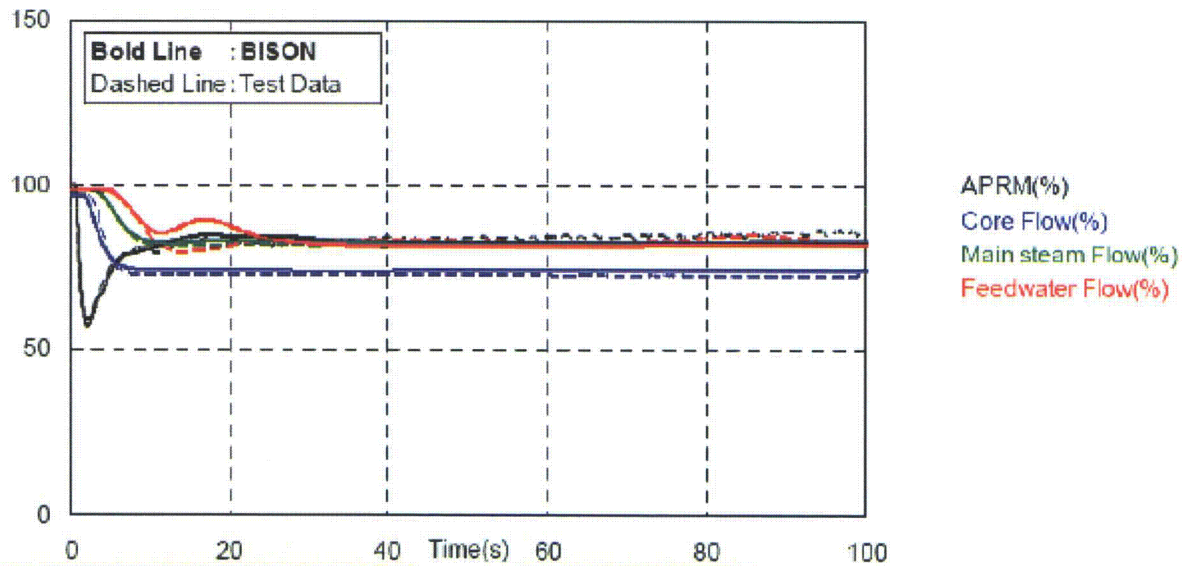
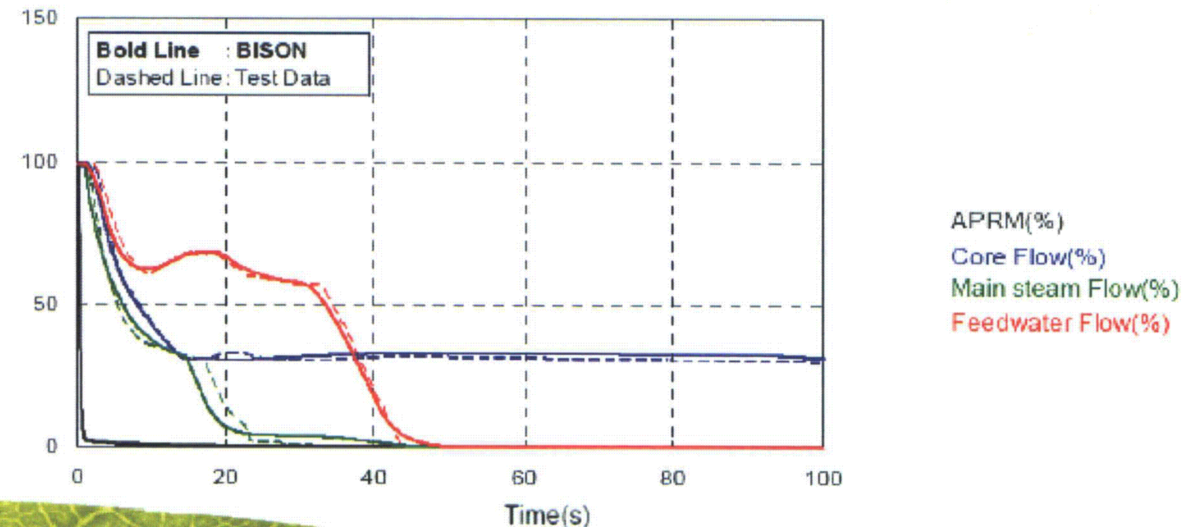
Removal of SER Restriction 2 (cont.)

- Reactor internal pump trip
- 3 out of 10 pumps trip, resulting in negative flow in the stopped pumps
- Good agreement for core flow



Removal of SER Restriction 2 (cont.)

- Generator Load Rejection
- 4 out of 10 pumps trip, resulting in negative flow in the stopped pumps
- Good agreement for core flow



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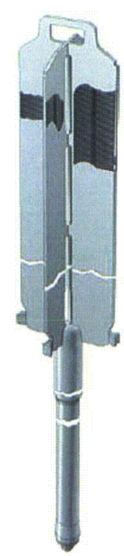
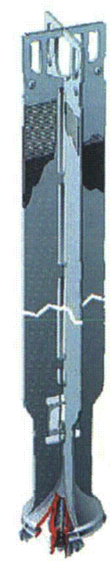
Advanced Control Rod Insertion Model





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Advanced Control Rod Insertion Model

- Qualification of the Westinghouse advanced control rod insertion model
- The model has been used extensively in Europe
  - ASEA-ATOM has used it for designing scram systems for the construction of BWRs
  - ABB-ATOM / Westinghouse has used it for BWR transient calculations in Europe for more than 20 years
- The model is general and can be adapted to different reactors

Advanced Control Rod Insertion Model (cont)

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Advanced Control Rod Insertion Model (cont)

- Included in the Topical is
  - A description of the general model
  - An example of an advanced control rod insertion model for ABWR
  - Validation of the advanced control rod insertion model
    - measured data from ABWR [ ] a,c
    - measured data from an European internal pump reactor

New Method for Cross-Section Evaluation

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New Method for Cross-Section Evaluation

- In BISON LTR RPA-90-90-P-A there are three methods for determining coefficients and polynomials used for cross-sections in BISON
    1. Single Fuel Type
    2. Multiple Fuel Types
    3. Collapse from 3D model
- Method #3 is accepted by USNRC to be used in final licensing analyses for US applications of limiting transients
- Method #2 is accepted by USNRC for sensitivity studies and ATWS

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New Method for Cross-Section Evaluation (cont)

- The topical presents an improvement to the "Multiple Fuel Types" method

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New Method for Cross-Section Evaluation (cont)

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New Method for Cross-Section Evaluation (cont)

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Pump Motor and Frequency Converter Models

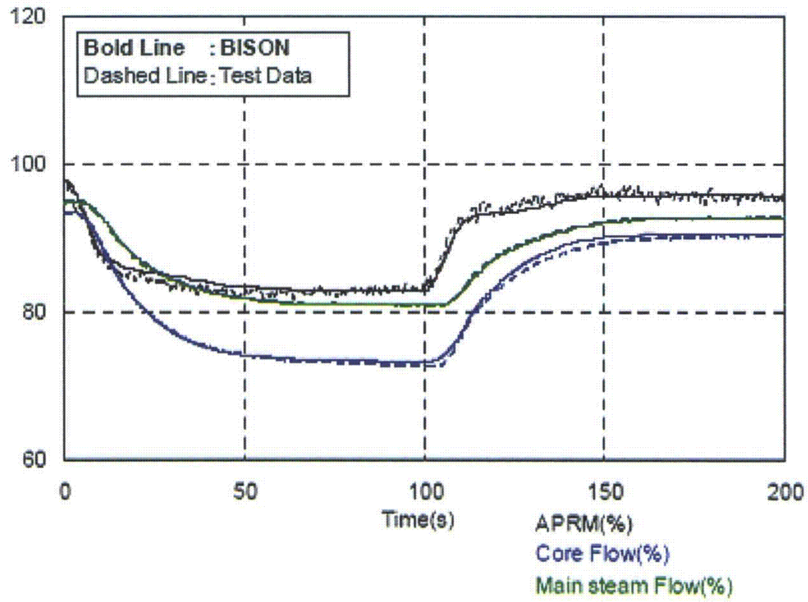
Pump Motor and Frequency Converter Models

- Additional models are needed to simulate internal recirculation pumps
- The Topical will contain a description of the recirculation pump model used for internal pump reactors
  - Asynchronous motor model
  - Pump motor controller
- ABWR model provided as an example
- The model has been used extensively in Europe for more than 30 years

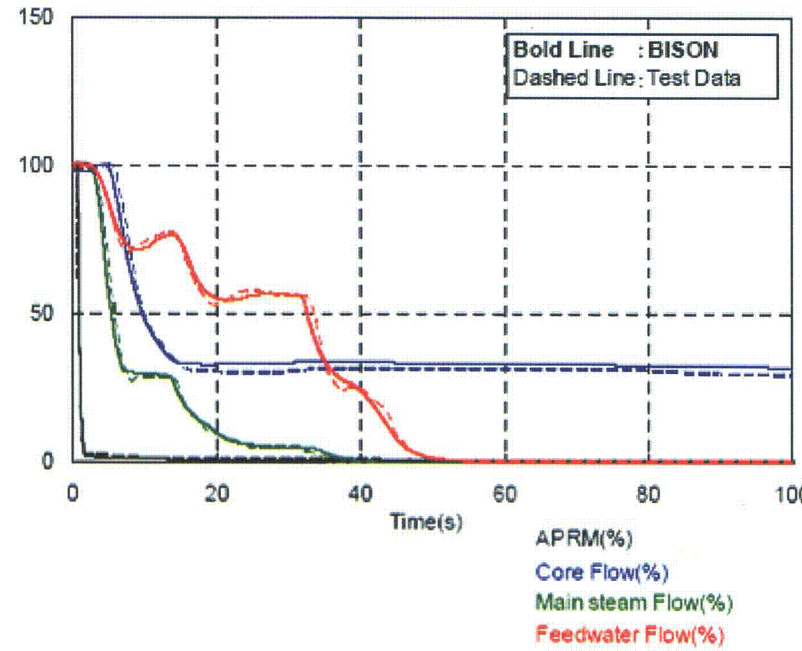
Pump Motor and Frequency Converter Models (cont)

- The model is validated against measurements from ABWR Hamaoka 5

Recirculation flow control system ramp change



Main steam isolation valve closure test



Level Measurement Model

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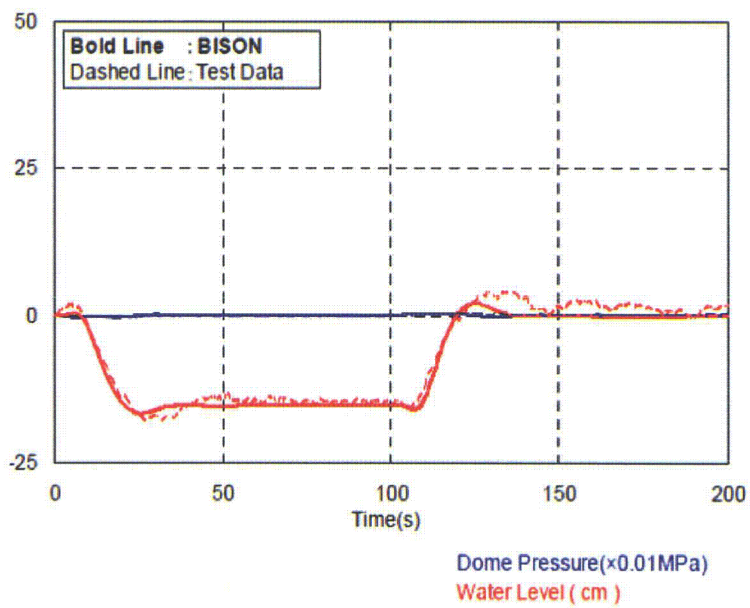
Level Measurement Model

- Level measurement model from system modeling tool SAFIR in BISON
  - SAFIR is described in Supplement 3 (WCAP-17079-P) to BISON LTR RPA-90-90-P-A
- Simulates the level measurement system in the plant, using pressure differences in the RPV downcomer
- The topical will include
  - Model description
  - Model validation

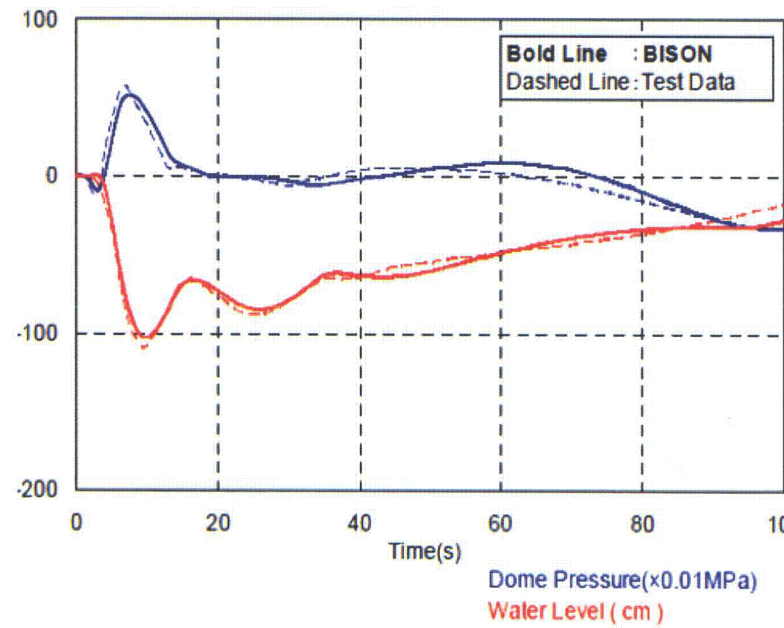
Level Measurement Model (cont)

- The model is validated against measurements from Hamaoka 5

Feedwater control system step change



Main steam isolation valve closure test



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Steam Condensation Model

Steam Condensation Model

- This new model introduces the effect of steam condensation on the water level in the reactor

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Steam Condensation Model (cont)

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Post Dryout and Rewet Models

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Post Dryout and Rewet Models

- Description and validation of model for calculating Peak Cladding Temperature

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Post Dryout and Rewet Models (cont)

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Post Dryout and Rewet Models (cont)

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Questions and Feedback

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LTR 3
WCAP-17203
Fast Transient and ATWS Methodology

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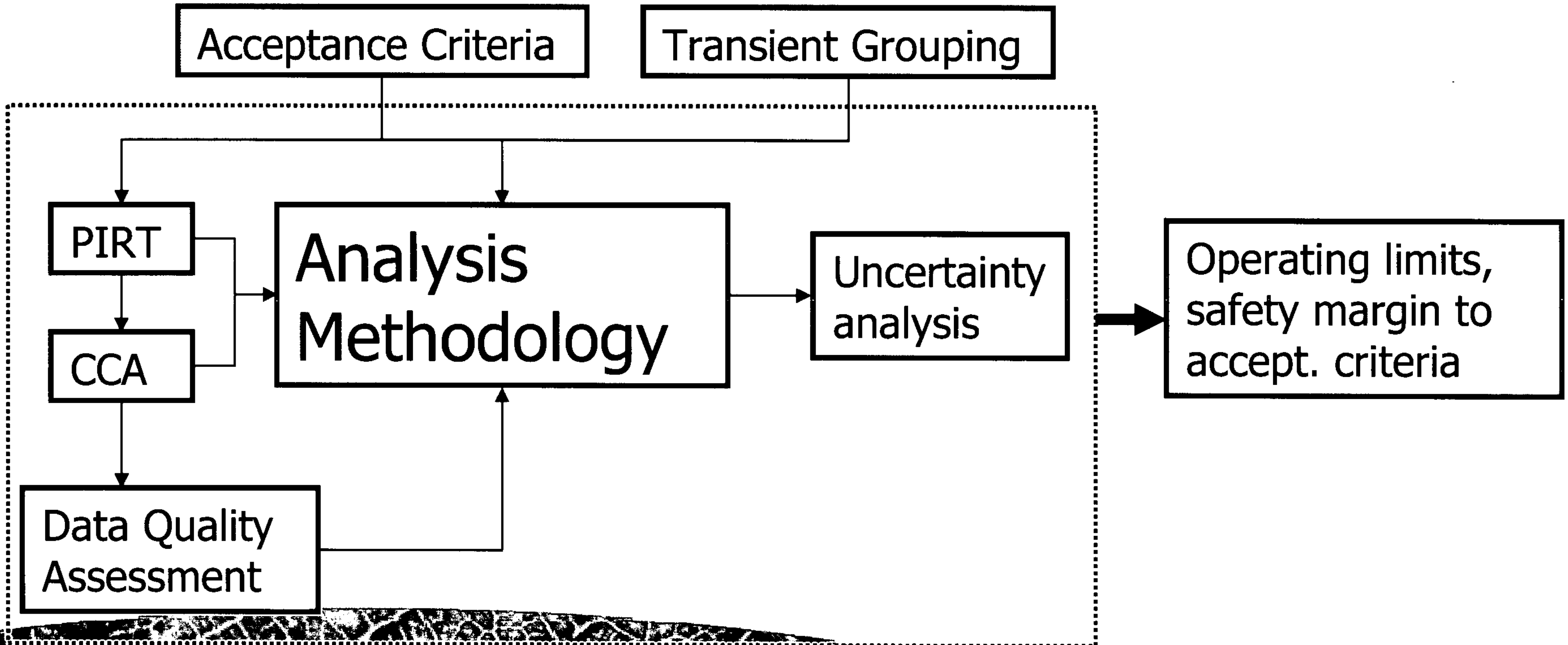
LTR 3 "Fast Transients and ATWS Methodology" for Ch. 15

- Objective of the Topical Report
  - Description of Complete Methodology for Fast Transients and ATWS Analysis including the evaluation of PCT
  - Introduction of Monte Carlo Uncertainty Evaluation Methodology
- Overview of the Topical Report
  - Analysis Methodology
  - Uncertainty Analysis
- Desired uses and applicability of the Topical Report
  - ABWR and BWR/2-6

LTR 3 - Table of Contents

Introduction

- LTR 3 (Evaluation) Methodology – how are the critical safety parameters evaluated? Alternatively stated - how the acceptance criteria are fulfilled.



Transient Groups and Types

- SRP Ch.15 fast transient events are grouped into the following categories
  - Pressure Increase/Decrease
  - Reactor Coolant Flow Increase/Decrease
  - Feedwater Flow Increase/Decrease
  - Reactor Coolant Temperature Increase/Decrease
  - ATWS
- Type of event defined by its phenomenological effect on the plant
- Power plant designs considered
  - ABWR
  - BWR/2-6

Acceptance Criteria and Figures of Merit

- Acceptance Criteria
  - AOO and ATWS Acceptance Criteria have been defined to meet the requirements related to the GDC specified in 10CFR50 Appendix A
- Figures of Merit
  - Derived from the acceptance criteria
  - Figures of Merit are used to judge importance of phenomena
- Operating Limits, Safety Margins to Acceptance Criteria
  - Evaluated parameters – OLMCPR, PCT etc

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Phenomena Identification and Ranking Table (PIRT)

- Identification of potentially important phenomena and plant components
- Ranking by impact on scale High/Medium/Low
- PIRT was developed with regards to impact on Figures of Merit, for each transient group
- PIRT is code independent. It is the consensus judgment of a Westinghouse subject-matter expert panel
- PIRT is included in this topical WCAP-17203

What is important?

Phenomena	Ranking		
xxx	H		
yyy		M	
zzz		M	
....			
mmm			L

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Code Capability Assessment (CCA)

- Provides a statement on a specific code capability to simulate the phenomena defined in the PIRT
- Establishment of the Assessment Base
- Ranks the code capability on High/Medium/Low scale
- CCA is code-dependent, for POLCA-T result is included in **LTR 4a** and **4b**

What is the code capability?

Capability	Ranking		
xxx	H		
yyy		M	
zzz	H		
….			
mmm			L

Data Quality Assessment (DQA)

- Based on Phenomena, establish the list of relevant code input and model parameters
- Define uncertainty distributions and/or bounding values for relevant parameters included in uncertainty analysis

What is the data quality?

Phenomena	Code Input Parameter	Data Quality				
		Min	BE	dist	stddev	Max
XXX	xxx.1					
	xxx.2					
	xxx.3					

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Analysis Methodology

- Limiting Plant States
- Code specific methodology
  - 1D and 3D
- Evaluation of operating limits (CPR, LHGR, etc.) and PCT
- Input data selection
- Uncertainty methodology
  - Non-parametric statistics method (Monte-Carlo)

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Limiting Plant States

- Each potentially limiting event is evaluated for the limiting plant condition(s) throughout the plant allowable operating domain

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- The event analysis is performed for these limiting plant operating states

Code Specific Methodology

- Depending on the code type selected, some basic code specific methodology has to be applied

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Code Specific Methodology (cont)

- 3D dynamic code (3D kinetics with parallel core channels)

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Evaluation of Operating Limits

- Example Operating Limit Minimum Critical Power Ratio (OLMCPR)

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Input Data Selection

- Methodology evaluation matrix:

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Conservative methodology settings

- For each transient group conservative settings are specified in LTR. This will guide the methodology for "conservative" selected inputs.

Uncertainty Analysis

- Confirms that the combined code and application uncertainty is less than the design margin for the particular event acceptance criterion
- This topical describes an additional method based on Monte Carlo approach
  - First proved by Wald (1943)
  - Recently adapted by Guba, Makai, and Pal (2003)
    - Frequently used method (Westinghouse LBLOCA Methodology)
  - Virtually assumption free
    - No requirements on input and output data distribution functions
    - Independent of the number of input parameters

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Non-Parametric Statistics Method

- Tolerance limit for event acceptance criterion is estimated with certain confidence by randomly sampling input and modeling parameters n-times
- Number of simulations is determined by desired tolerance limit and confidence interval.
- Example: Evaluation of single operating limit (PCT)
  - Acceptance Criterion for PCT is 2200F
  - Input and modeling parameters are sampled 59 times and PCT is calculated for each case
  - The non-parametric statistics method calculates the 95th percentile on 95% confidence level as the largest PCT from 59 calculations. If this value is below the design basis (2200F) then the event acceptance criterion is fulfilled

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Non-Parametric Statistics Method (cont)

- Following is the relation between the desired tolerance interval, confidence level and number of runs (for single parameter and one sided tolerance interval):

$$\gamma = 1 - \beta^{n}$$

γ – Confidence level

β – Tolerance interval

n – number of code runs

- If γ=0.95 and β=0.95 then the solution for n is n=59

Non-Parametric Statistics Method (cont)

- If the k^{th} largest value is taken as an estimate of 95^{th} percentile on 95% confidence level, then the number of runs must be increased such that the following equation is fulfilled for n:

$$\gamma = 1 - \sum_{i=0}^{k-1} \binom{n}{i} (1-\beta)^i \beta^{n-i}$$

Estimator grade (k)	Number of runs, n (95/95)
1	59
2	93
3	124
4	153
5	181

Non-Parametric Statistics Method (cont.)

- In case of several operating limits evaluated simultaneously, the number of code runs is defined by the following equation:

$$\gamma = \sum_{i=0}^{n-p} \binom{n}{i} \beta^{i} (1-\beta)^{n-i}$$

γ – Confidence level

β – Tolerance interval

n – number of code runs

p – number of parameters evaluated simultaneously

- Method commonly used in Westinghouse:

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Non-Parametric Statistics Method (cont)

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Non-Parametric Statistics Method (cont)

Advantages

- Relatively small number of code runs
- Robust
- Virtually assumption free
  - No knowledge about the shape of input/output distribution function
  - Output parameter distribution function – continuous

Disadvantages

- Risk for over-conservatism when low-order estimator used
  - This is compensated by increasing the number of code runs

Summary

- Westinghouse methodology for evaluating transients and ATWS events presented
- Methodology defined in a code-independent way, applicable to both 1D and 3D codes
- An additional uncertainty evaluation method presented

Questions and Feedback

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LTR 4a
WCAP-16747 Appendix C
POLCA-T Application for AOO Transient Analysis

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LTR 4a "POLCA-T Application for AOO Transient Analysis"

- Objective of the Topical Report
  - NRC approval of POLCA-T for use in AOO transient analysis
- Overview of the Topical Report
  - AOO scenario specification
  - AOO verification and validation
- Desired uses and applicability of POLCA-T for AOO transient analysis
  - ABWR's and BWR/2-6

Table of Contents

Power Plants Specification

- Westinghouse is seeking review and approval of POLCA-T for use in licensing AOO transient analysis of
  - ABWR (internal pumps)
  - BWR/2-6 (external pumps and jet pump loops)

Transient Scenario Specification

- Anticipated Operational Occurrences i.e. transient events that are expected to occur one or more times during the life of plant as stipulated in 10CFR50 Appendix A.

- For the Evaluation Model development, the AOOs were grouped into four phenomenological categories according to event type
  - pressure increase/decrease (PI/PD)
  - reactor coolant flow increase/decrease (RI/RD)
  - feed water flow increase/decrease (FI/FD)
  - reactor coolant temperature increase/decrease (TI/TD)

Transient Scenario Specification (cont)

- AOO event categorization for EM development and correspondence to Standard Review Plan (SRP)

Event category	**Abbr.**	**SRP section**	
Pressure increase/decrease	PI/PD	15.1.2 15.1.3 15.1.4 15.2.1 15.2.2 15.2.3 15.2.4 15.2.5 15.2.6 15.6.1	Increase in feed water flow Increase in steam flow Inadvertent opening of a safety/relief valve Loss of external load Turbine trip Loss of condenser vacuum Closure of main steam isolation valve Steam pressure regulator failure (closed) Loss of non-emergency AC power to station auxiliaries Inadvertent opening of a pressure relief valve (also covered by 15.1.4)
Reactor coolant flow increase/decrease	RI/RD	15.3.1-2 15.3.3 15.3.4 15.4.4 15.4.5	Loss of forced reactor coolant flow including trip of pump motor and flow controller malfunctions Reactor coolant pump rotor seizure Reactor coolant pump shaft break Startup of an inactive recirculation pump at an incorrect temperature Flow controller malfunction causing an increase in core flow rate
Feed water flow increase/decrease	FI/FD	15.2.7	Loss of normal feed water flow
Reactor coolant temperature increase/decrease	TI/TD	15.1.1 15.5.1	Decrease in feed water temperature Inadvertent operation of ECCS

Acceptance Criteria

- AOO Acceptance Criteria have been defined to meet the requirements related to the GDC specified in 1OCFR50 Appendix A
  - Specified Acceptable Fuel Design Limits (SAFDL's)
    - Clad overheating
    - Clad strain
    - Fuel temperature for centerline melting
    - Peak fuel enthalpy for rapid energy deposition
  - Radioactive effluents
    - POLCA-T input/results can be used for analysis with a NRC-approved method
  - Peak RCPB Pressure
    - The ASME Code 110% LIMIT of the design pressure
  - Suppression Pool Temperature
    - POLCA-T input/results can be used for analysis with a NRC-approved containment code

Figures of Merit

- Figures of Merit for AOO
  - MCPR (for clad overheating)
  - LHGR (for clad strain)
  - Peak RCPB Pressure

Verification and Validation

- In addition to previous NRC review of WCAP-16747-P, LTR4a includes AOO specific V&V for desired functionality (CPR) and communication with adjacent systems (SAFIR)
  - Plant data tests
  - Separate effect tests
  - Analytical test case

Verification and Validation (cont)

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Verification and Validation (cont)

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Verification and Validation (cont)

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Verification and Validation (cont)

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Verification and Validation (cont)

a,c

Verification and Validation (cont)

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Verification and Validation (cont)

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The AOO Analysis and Uncertainty Methodology

- The AOO Analysis and Uncertainty Evaluation Methodology according to Fast Transient and ATWS Methodology Topical Report

Summary

- Licensing Topical Report 4a (WCAP-16747 Appendix C):
  - POLCA-T Application for AOO Transient Analysis
- The purpose
  - Approval of POLCA-T use in AOO Transient Analysis for ABWR and BWR/2-6
- Figures of Merit for AOO events:
  - MCPR (for clad overheating)
  - LHGR (for clad strain)
  - Peak RCPB Pressure
- Assessment Base for AOO events includes Plant Data, Separate Effects, and Analytical Tests

Questions and Feedback

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LTR 4b
WCAP-16747 Appendix D
POLCA-T Application for ATWS Analysis

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LTR 4b "POLCA-T Application for ATWS Analysis"

- Objective of the Topical Report
  - NRC approval of POLCA-T for use in ATWS analysis
- Overview of the Topical Report
  - ATWS scenario specification
  - ATWS verification and validation
- Desired uses and applicability of the Topical Report
  - ABWR and BWR/2-6

Table of Contents

Power Plants Specification

- Westinghouse is seeking review and approval of POLCA-T for use in licensing ATWS analysis of:
  - ABWRs (internal pumps)
  - BWR/2-6 (external pumps and jet pump loops)

ATWS Scenario Specification

- Anticipated Transients Without Scram (ATWS) is an Anticipated Operational Occurrence (AOO) followed by the failure of the reactor trip portion of the protection system (10CFR50 Appendix A)
- Qualification for analysis of ATWS type of scenarios:
  a) Alternate Control-Rod Insertion (ARI)
  b) Fine-Motion Control Rod Drive[1] (FMCRD) run-in
  c) Standby Liquid Control System (SLCS) start-up. ARI and FMCRD failure

[1]If included in the design

ATWS Acceptance Criteria

- POLCA-T evaluation of ATWS acceptance criteria (ATWS Rule of 10CFR50.62 and CFR50.46)
  - Fuel integrity
    PCT (2200°F) and local oxidation (17%)
  - RCPB integrity:
    Reactor coolant pressure boundary limits (ASME)
  - Containment Integrity
    Pressure & temperature design limits. POLCA-T provides input to containment code.
  - Long-Term Shutdown Cooling
    Reactor Brought to a safe shutdown condition, cooled down and maintained in cold shutdown. POLCA-T analyses the reactor core and RCPB integrity.

Figures of Merit

- Figures of Merit for ATWS
  - PCT
  - Peak RCPB pressure
  - Mass and energy release to containment

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Model Assessment

- ATWS assessment base extends the AOO qualification
- Specific POLCA-T ATWS assessment includes data from integral effects tests, plant data as well as analytical test
- The ATWS model is being used in Europe to meet the latest ATWS requirements

Plant Data Qualification

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[ ]a,c Preliminary Calculation

[ ]a,b,c

Integral Effects Test

a,c

[ ]

Analytical Test

Evaluation of boron mass transport model for POLCA-T

a,c

Specific ATWS Assessment Base

Analytical test model

a,c

Boron Transport Verification Test, Nodalization Study

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Boron Transport Verification Test

Conclusions

[ ][a,c]

The ATWS Analysis and Uncertainty Methodology

- The ATWS Analysis and Uncertainty evaluation Methodology according to Fast Transient and ATWS Methodology Topical Report

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Summary

- Licensing Topical Report 4b
  - POLCA-T Application for ATWS Analysis including all scenario types
- The purpose
  - Approval of POLCA-T use in ATWS Analysis for ABWR and BWR/2-6
- Figures of Merit for ATWS events
  - PCT
  - Peak RCPB pressure
  - Mass and energy release to containment
- Assessment base for ATWS events include data from integral effects tests, plant data as well as analytical test

Questions and Feedback

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LTR11
ABWR Control Rod

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LTR 11 "Control Rod Blades for ABWR"

- Objective of the Topical Report
  - Extend the topical report approval of CR 82M-1 and CR 99 to N-lattice type of plants (ABWR)
- Overview of the Topical Report
  - Design Requirements
  - Materials Evaluation
  - Mechanical Evaluation
  - Physics Evaluation
  - Operational Evaluation
- Desired uses and applicability of the Topical Report
  - Extend Topical applicability to ABWR

Introduction

- Desired Outcomes
  - Provide an update to the NRC on the plans for Control Rod Blades (CRB) for ABWR
  - Provide NRC reviewers with an understanding of the CRB for ABWR
  - Receive feedback from NRC

Licensing History of Westinghouse CRBs

- UR 85-225-A, "ASEA-ATOM Control Rods for US BWRs," CR 82 use in D-Lattice (February 1986)
- UR 88-081-A, Supplement 1 to Topical Report UR 85-225-A, approved CR 82 use in C-Lattice (May 1988)
- US 88-068-A, Supplement 2 to Topical Report UR 85-225-A, approved CR 82 use in S-Lattice (August 1989)
- CR-82M-1 introduced through 50.59 evaluation process (re: ABB Report BKE 95-044, March 1995)
  - CR 82M-1 and CR 82 differs only in blade wing material
    - CR 82M-1, 316L stainless steel
    - CR 82, 304L stainless steel

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Licensing History of Westinghouse CRBs (cont)

- CR 99 Licensed through WCAP-16182, for use in D-, C- and S-Lattice, approved 2004

a,c

- WCAP-16182 Rev. 1, life extension of CR 99, under NRC licensing review
  - Methodology applicable for all Westinghouse CRBs

Design CR 82M-1

a, c

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Design CR 99

a, c

Scope

- The new ABWR N-lattice control rod blade topical will use the stress methodology under review in WCAP-16182-P-A Rev. 1
- This methodology will apply to both the CR 99 and CR 82M-1 control rod blade designs
- This topical will be a supplement to WCAP-16182-P-A Rev. 1

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Tasks to Be Performed

- Add description of Westinghouse CRB for N-lattice
  - Coupling
  - Handle
- Review and compare the load cases for N-lattice control rods with S-lattice control rods
  - Perform additional stress analysis where conditions differs (e.g. scram load)
- Review and compare reactivity worth for N-lattice control rods with S-lattice control rods
  - Secure shut down margin

Table of Contents

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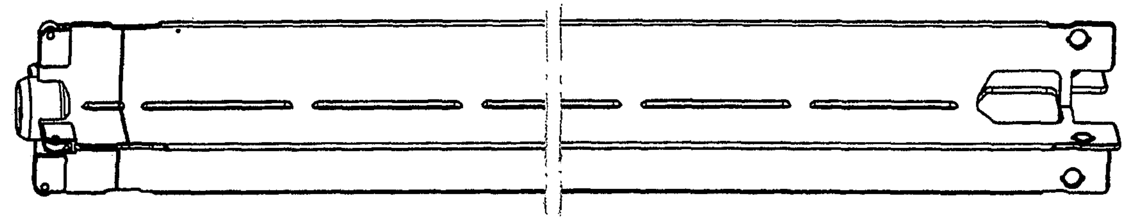
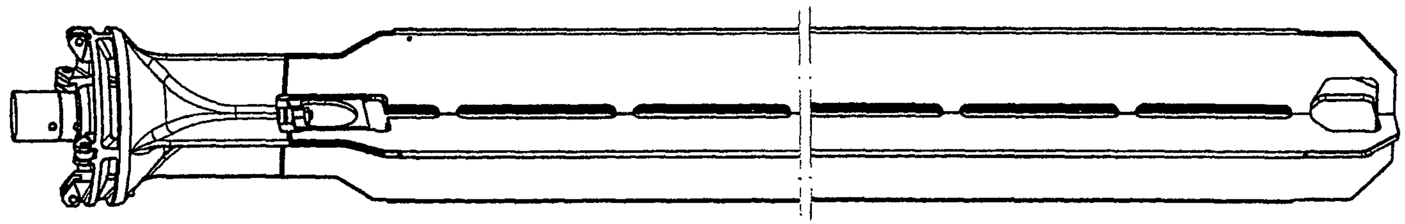
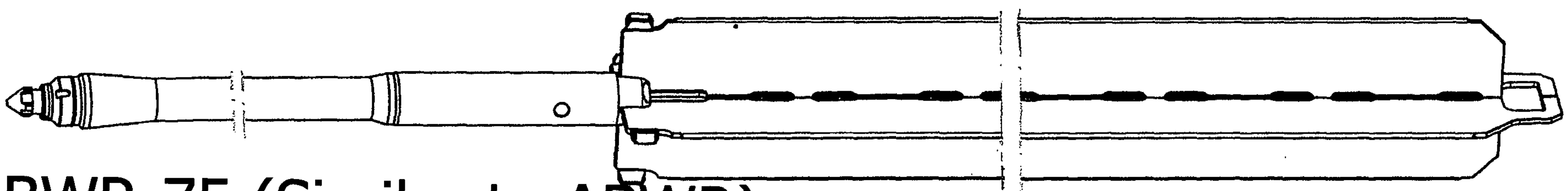
N-lattice vs. S-lattice and BWR-75-lattice

N-lattice (ABWR)



S-lattice





BWR-75 (Similar to ABWR)

N-lattice vs. S-lattice and BWR-75-lattice (cont)

- N-lattice control rod differs from an S-lattice control rod in: a,c

Methodologies

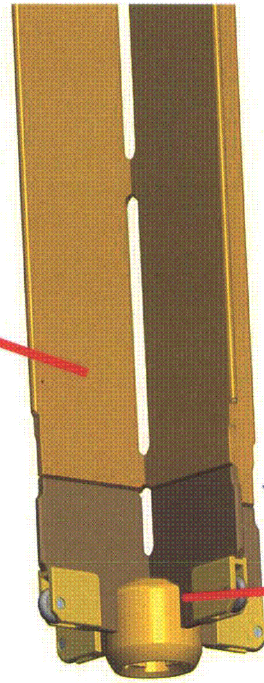
- Stress analysis

a,c

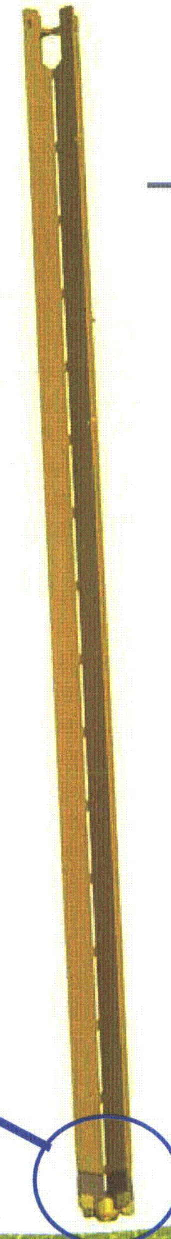
[ ]

Examples of Stress Analysis

a,c



a,c



Stresses derived during scram load,
analyzed due to elevated design load for ABWR

Methodologies

- Physics Evaluation
  - Reactivity worth and shut down margin evaluation is done using Westinghouse procedures according to US approved methodology
  - [ ]a,c handle has limited nuclear impact and is easily treated through approved Westinghouse Lattice Code

Summary

- ABWR Control Rod Supplement LTR adds N-lattice (ABWR) to existing approved Westinghouse CRBs in D-, C- and S-lattice reactors
  - Mechanical Design
  - Stress analysis
  - Nuclear physics analysis

Questions and Feedback

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