ENCLOSURE 2

MFN 04-005

GENE Presentations for ACRS Thermal Hydraulic Subcommittee, January 15, 2004 (non proprietary)

1. ESBWR Program Overview, Atam Rao, January 15, 2004
2. ESBWR TRACG Approval Process, Bob Gamble, January 15, 2004
3. ESBWR Test Program Overview, Bob Gamble, January 15, 2004
4. TRACG Applicability for ESBWR LOCA Analysis, Bharat Shiralker, January 15, 2004

GE Nuclear Energy

ESBWR Program Overview

Atam Rao
Manager, New Reactor Development, GENE
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ACRS Thermal Hydraulics Sub-committee Meeting
Jan 15, 2004,
Rockville, Maryland

Outline

- Program Overview
  - Stepwise Program with Passive Safety Systems Methodology Closure as First Step – Simplifying the Design Certification Process
  - Increased Emphasis on Developing ESBWR as the Plant of Choice
- ESBWR Design Overview
  - Simpler with More Margin – by design
- Safety Analyses Methodology
  - Single Integrated Computer Code – TRACG- used for analysis with well defined Application Methodology
  - Completed Testing and Qualification Program
- Summary and Conclusions

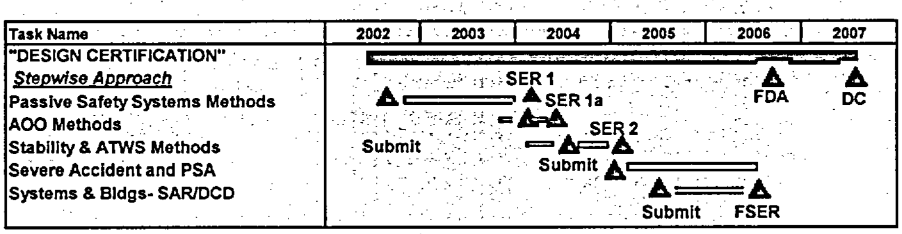
An inherently simpler and safer design
An efficient plan for closure to meet utility needs
Focus on what is important

ESBWR Program Overview

- Stepwise program for design development
  - Developed passive systems
  - Developed integrated plant design – SBWR
    - Completed extensive system and building design
    - Defined extensive test and analysis program
    - Completed extensive test and analysis program
  - Improved plant economics and design - ESBWR
    - Plant optimization and economies of scale
    - Incorporated utility requirements
    - Utilize ABWR experience – components, construction
- Stepwise program for "Design Certification"
  - Simpler with more margin – by design
  - Methods Approval – pre-application review
    - Single Integrated Computer Code for Analyses
    - Safety Evaluation Report for TRACG
  - Safety analysis report & design certification – after methods approval

GE is committed to develop and rapidly certify the ESBWR

ESBWR Design Certification Schedule



- Emphasis on closure and simplifying NRC reviews
  - Methods approval for new features
  - Minimize or eliminate design changes during review
- ESBWR Design
  - Simpler with More Margin – by design

A practical schedule has been proposed

Goals for the Methods Approval

- Approval for the use of TRACG for ESBWR analyses
  - vessel response to pipe break – loss of coolant accident (ECCS/LOCA)
  - containment response to pipe break (Containment/LOCA)
  - vessel response to anticipated operational occurrences (AOO)
  - plant response to anticipated transients without scram (ATWS) and stability
- Confirmation of the adequacy of TRACG
  - adequacy of the qualification base and approach
  - no additional testing required

Approval covers TRACG code and Application Methodology

Comparison of Key ESBWR Parameters to Operating BWRs

Parameter	BWR/4-Mk I (Browns Ferry 3)	BWR/6-Mk III (Grand Gulf)	ABWR	ESBWR
Power (MWt/MWe)	3293/1098	3900/1360	3926/1350	4000/1390*
Vessel height/dia. (m)	21.9/6.4	21.8/6.4	21.1/7.1	27.7/7.1
Fuel Bundles (number)	764	800	872	1020*
Active Fuel Height (m)	3.7	3.7	3.7	3.0
Power density (kw/l)	50	54.2	51	54*
Recirculation pumps	2(large)	2(large)	10	zero
Number of CRDs/type	185/LP	193/LP	205/FM	121*/FM
Safety system pumps	9	9	18	zero
Safety diesel generator	2	3	3	zero
Core damage freq./yr	1E-5	1E-6	1E-7	1E-7
Safety Bldg Vol (m^3/MWe)	115	150	160	70

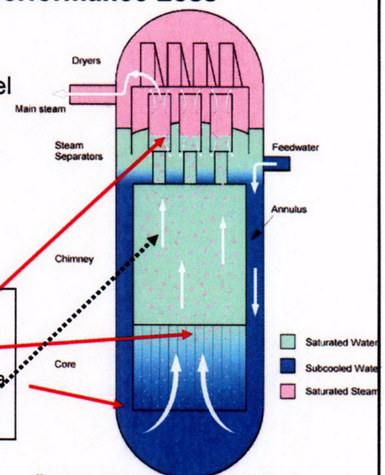
**Subject to change – ongoing optimization program*

Evolution Within a Small Range Minimizes Operational Risks

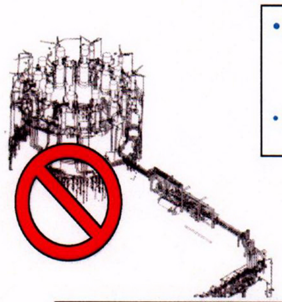
C01

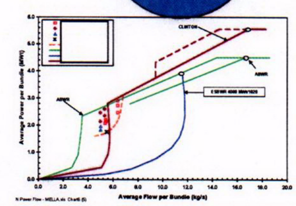
Natural Circulation – Simplification Without Performance Loss

- **Passive safety/natural circulation**
  - Put the water in the vessel – larger vessel
  - Increase driving head – larger vessel
- **Significant reduction in components**
  - Pumps, motors, controls, HXers
- **Load following with Control Rod Drives**
  - Minimal impact on maintenance



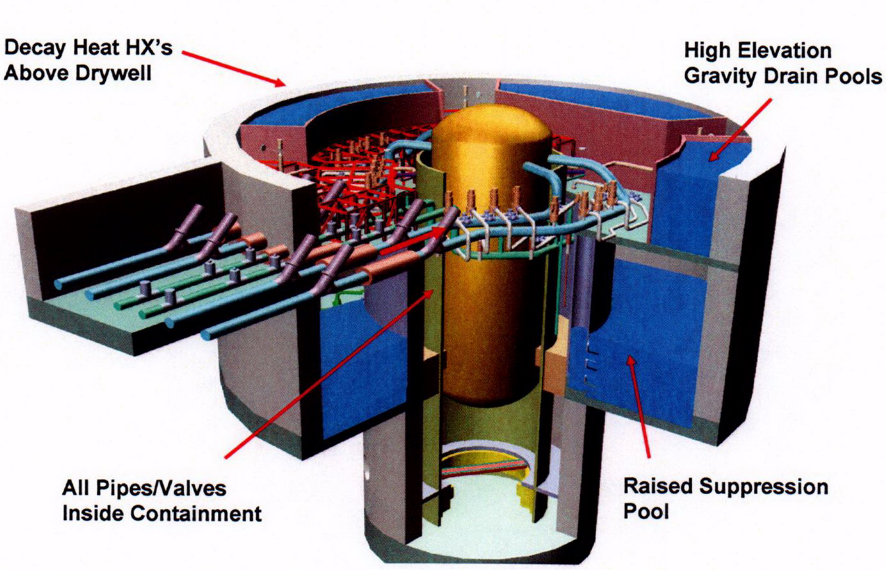
- Reduced flow restrictions
  - Improved separators
  - Shorter core
  - Increase downcomer area
- Higher driving head
  - Chimney/taller vessel



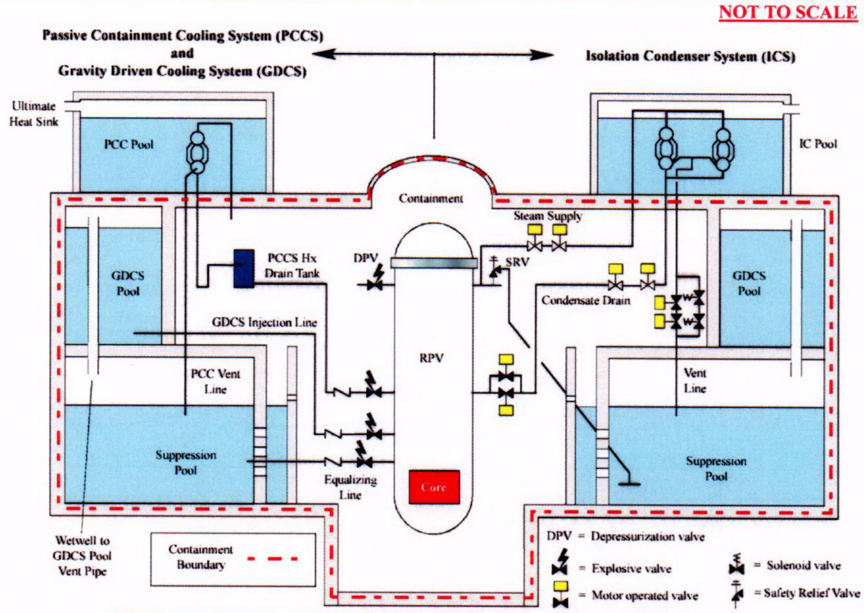


Enhanced Natural Circulation Compared to Standard BWR's

Passive Safety Systems Within Containment Envelope



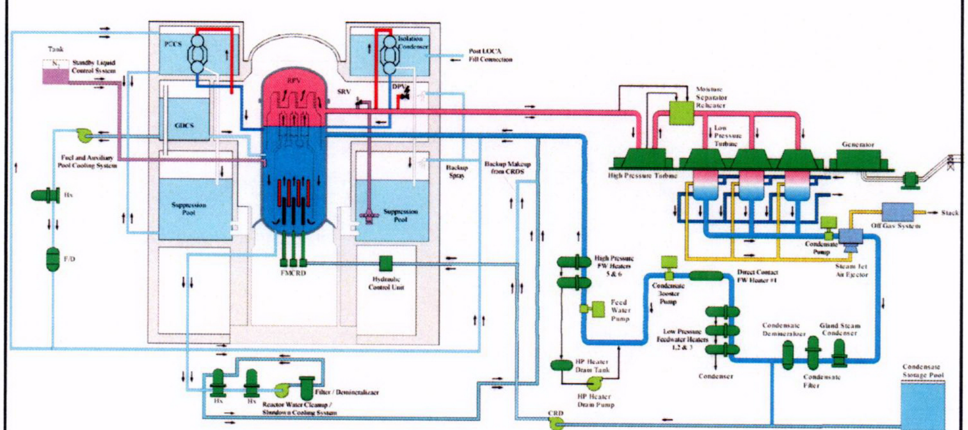
C02



Passive systems simplify the plant, reduce maintenance & increase security

AR- 9

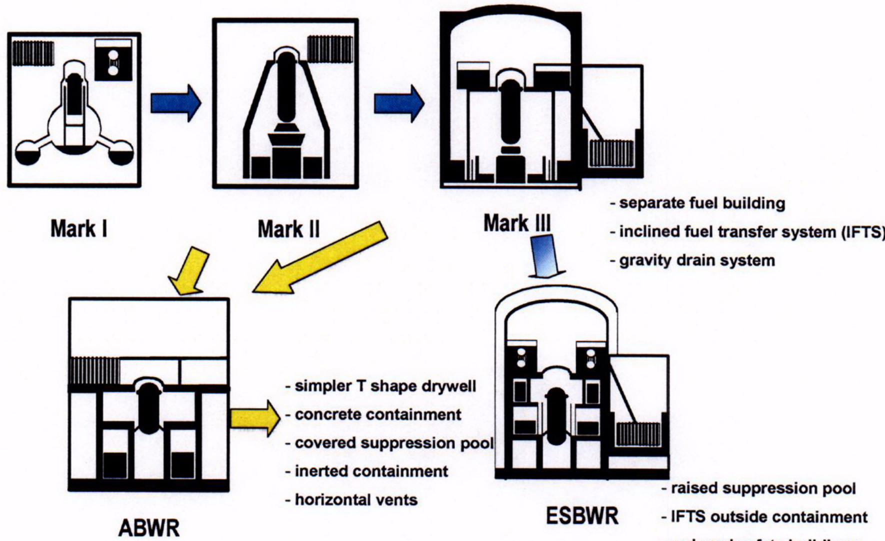
ESBWR Plant Schematic



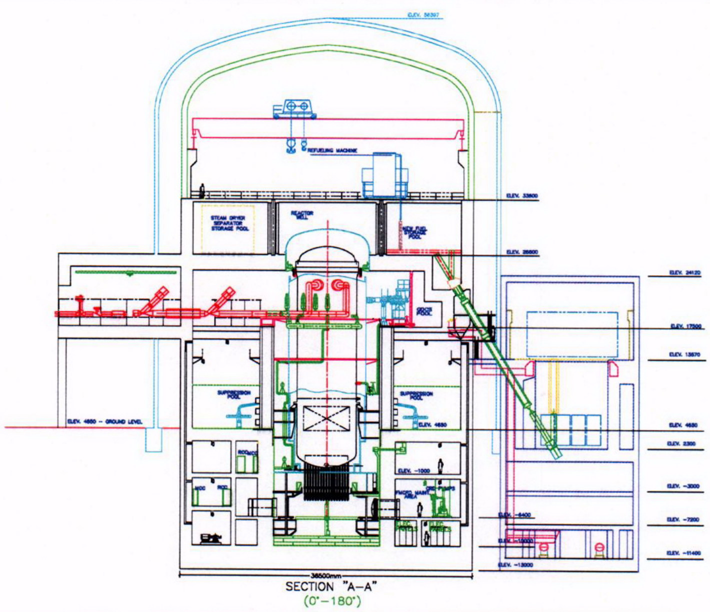
A Typical but Simpler Direct Cycle Plant

C03

Evolution of BWR Containments and Reactor Buildings

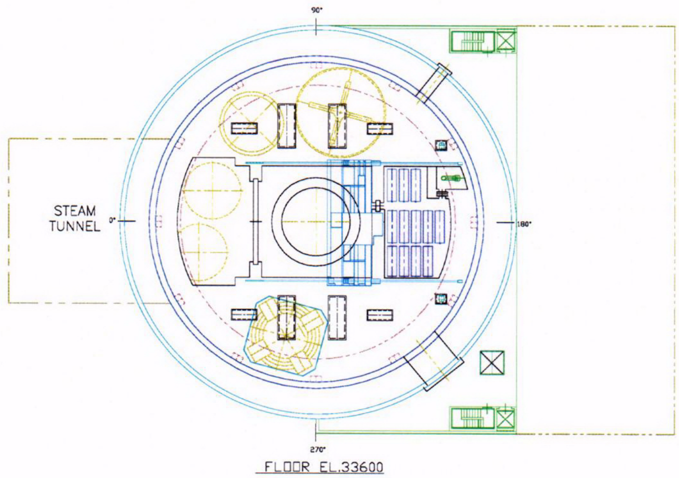


Evolution and Innovation Towards Simplicity



Smaller structures – less equipment with good access
Separate fuel building and improved security

C04



Refueling floor arrangement controls building size.
Improved fuel storage and transfer system

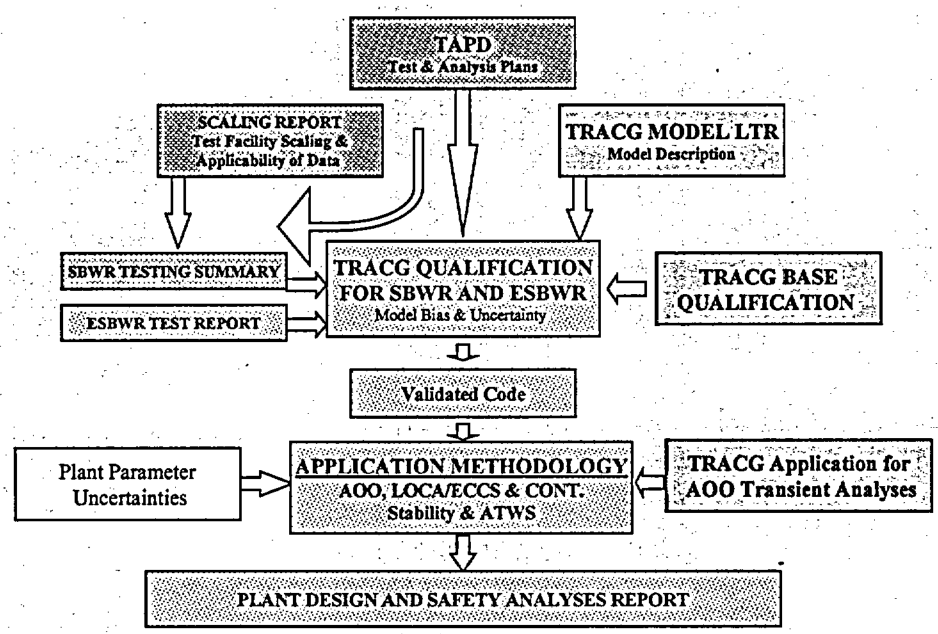
ESBWR and BWR Analyses Methods

Analysis Type	Analysis Method	
	BWR	***ESBWR***
Steady state	ISCOR	ISCOR
Transients		
· Pressurization	TRACG	TRACG
· Loss of feedwater heating	PANACEA	PANACEA
ATWS	ODYN/TASC	TRACG
Stability	ODYSY/TRACG	TRACG
LOCA/ECCS	SAFER	TRACG
LOCA/containment		
· Pressure/temperature response	M3CPT/SUPERHEX	TRACG
· Loads	Approved Methodology	Approved Methodology

TRACG – an integrated proven code - used for most analyses for ESBWR

C05

ESBWR Methods Approval Program Elements



Overview of key steps

- TRACG models
  - A few models determine plant response
  - A handful of key models are empirical
- Qualification
  - Extensive qualification of code
- Application Methodology
  - Different breaks and failures evaluated

Approval for TRACG w Application Methodology

Strategy for Determination of Test & Analysis Needs

- Develop list of governing phenomena and system interactions
- Top-Down Process based on plant accident/transient scenarios
  - Determine key phases of transients
  - List potentially important phenomena
  - Expert group ranking phenomena (PIRT)
- Bottom-Up process based on all unique ESBWR design features
  - Determine associated phenomena/system interactions
  - Evaluate and rank issues by importance
  - Supplements PIRT ranking approach to fill any gaps by focusing on ESBWR-unique features
- Consolidate highly ranked phenomena and system interactions
- Evaluate capability of analysis models & testing plans
  - Implement any needed models or bounding modeling procedures
  - Fill in testing gaps
  - Evaluate uncertainties to establish appropriate design margins

Rigorous process followed to define technology plan

Overview of Passive Plant Test Programs

- **Component Tests**

  PANTHERS/PCC (FULL SCALE)
  - Full-scale prototype performance tests
  - Steady state and transient tests with heavy (air) and light (helium) noncondensibles

  PANTHERS/IC
  - One of two modules of a full scale unit
  - Steady state, startup and transient tests

  PANDA PCC Tests (S Series) (1/50scale)
  - 10 steady state tests

  DPV Tests (FULL SCALE)
  - Performance tests of prototype valve

  Vacuum Breaker Tests
  - Performance tests of prototype valve

- **Integral System Tests**

  GIST (1/1000 scale)
  - 26 ECCS/LOCA integral tests with GDCS from wetwell pool

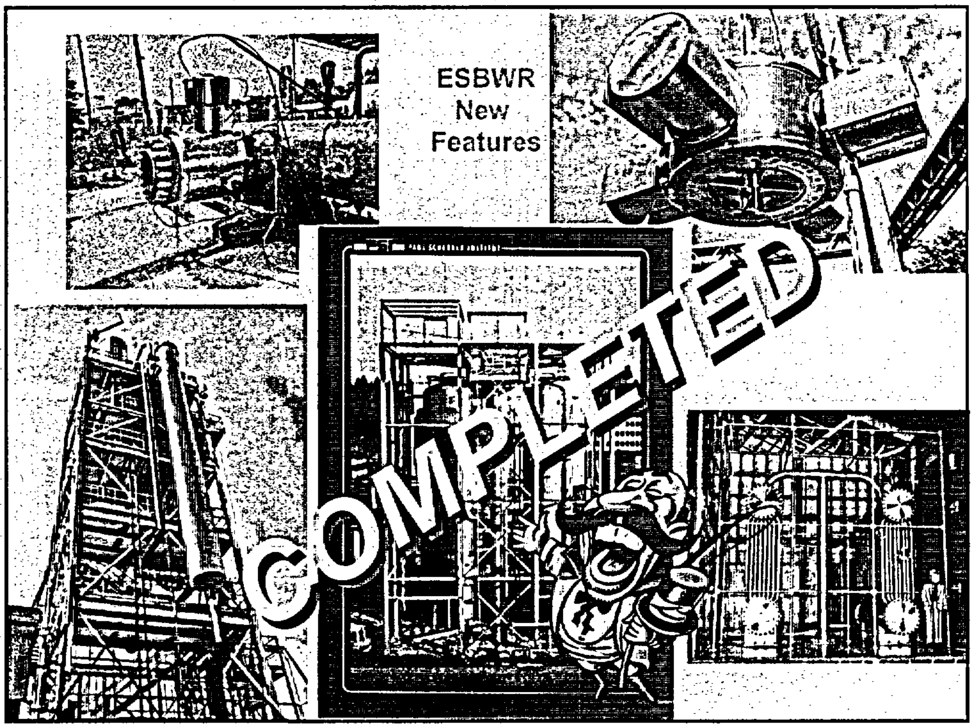
  GIRAFFE Step 3 (1/800 scale)
  - Long term containment response

  GIRAFFE/Helium (1/800 scale)
  - Long term containment response with light noncondensible gas

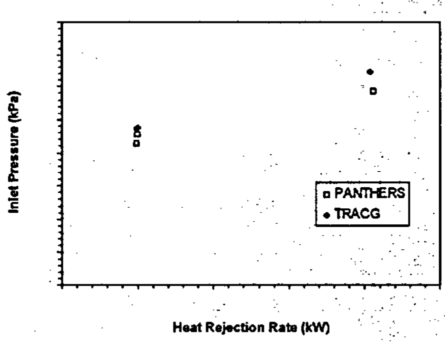
  GIRAFFE/SIT (1/800 scale)
  - ECCS/LOCA and containment integral tests with SBWR configuration (GDCS pool in drywell)

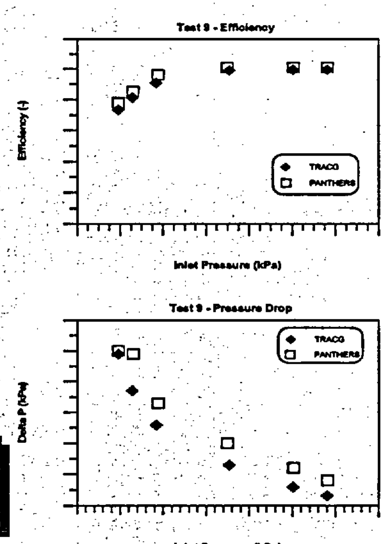
  PANDA (1/50 scale) M Series
  - Long term containment response

Extensive tests at different scales in different facilities



TRACG comparisons for PANTHERS PCC Tests - with & w/o non-condensibles





TRACG predicts component tests accurately for different test conditions

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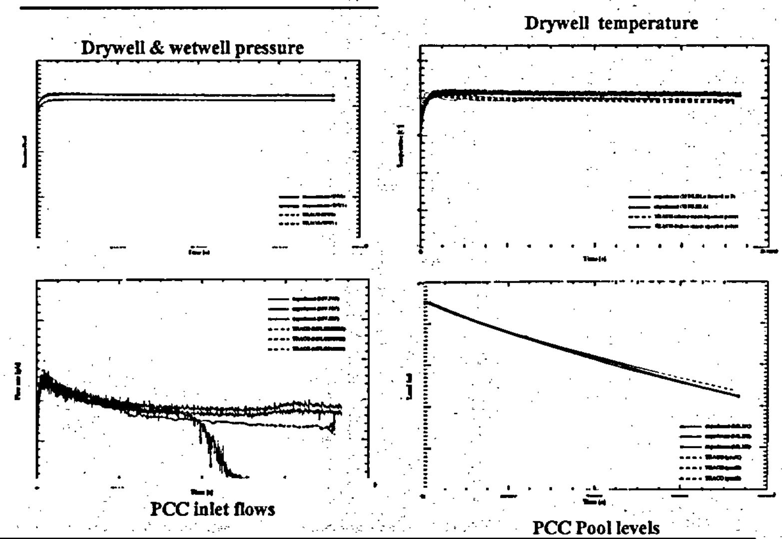
TRACG comparison to PANDA Test M3



TRACG predicts figure of merit and details accurately

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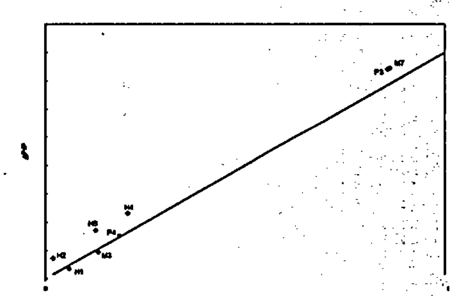
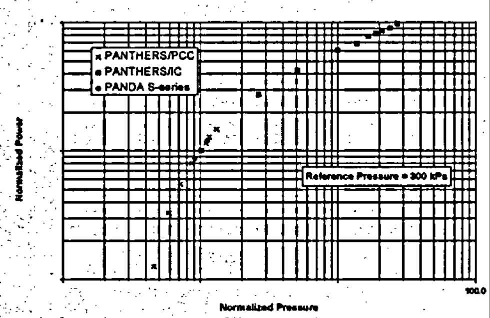
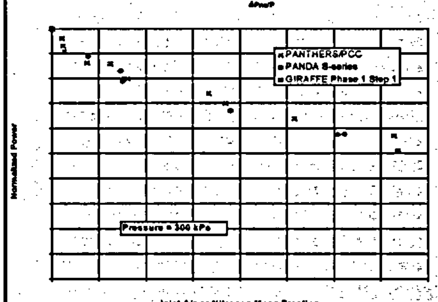
Effect of Scale on test results







- PCC/IC's are Readily Scalable
  - PANDA IC/PCC is a section of PANTHERS IC/PCC
  - PANTHERS PCC is a slice of ESBWR PCC
  - GIRAFFE PCC has different header configuration
- Containment pressure varies with non-condensable gas quantity in wetwell for different scales and different gases

Tests at different scale show similar results

TRACG Qualification Summary

- All qualification activities identified in test and analysis plan have been satisfactorily completed
  - "generic qualification" studies have been reviewed and accepted by NRC for AOOs for operating plants
  - Significant additional qualification has been performed, particularly for long term containment response
  - Accuracy of models has been quantified for prediction of key parameters
- Model limitations have been identified and bounding approaches developed to treat these limitations
- TRACG is qualified for ESBWR analysis with appropriate application procedures

A comprehensive qualification program has been completed

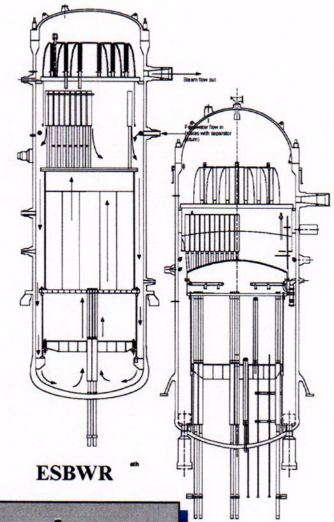
Safety Analyses Methods Program Summary

- Passive safety systems have simplified the plant design
- Plant evaluations are simpler
  - Less complex analyses
  - Low sensitivity to uncertainties
  - Substantial margins exist in the design
  - Improved integrated code shows better performance
  - Defense in depth systems provide additional back-up
- Extensive qualification of TRACG

Performance improved by design features
Improved performance assessed by qualified methods

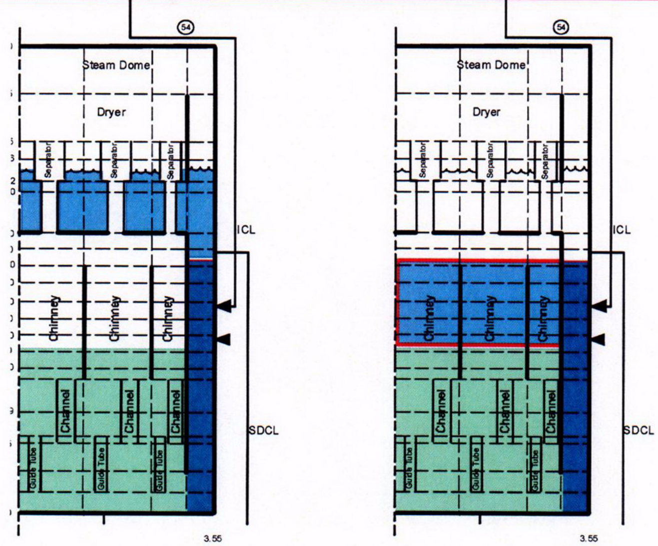
Design Features Affecting Plant Response

	ESBWR	ABWR	BWR5	BWR4
Large pipes below core	No	No	Yes	Yes
Core height, m	3.05	3.66	~3.66	~3.66
TAF above RPV bottom	~ 1/4	~ 1/2	~1/2	~1/2
Separator standpipes	Long	Short	Short	Short
Vessel height, m	27.7	21.1	~21.9	~21.8
Water volume outside shroud (above TAF), m³	222	88	94	92



Larger water inventory - improved plant LOCA performance
Larger steam volume – improved transient performance

Substantial Initial Water Inventory inside RPV



Collasped Levels at time = 0.0 sec

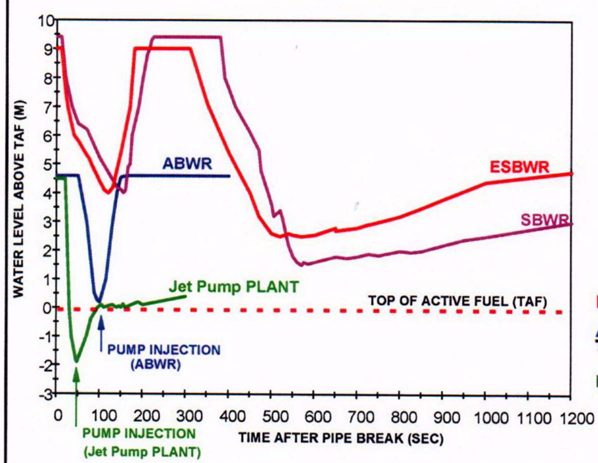
Collasped Levels at time ~ 20.0 sec

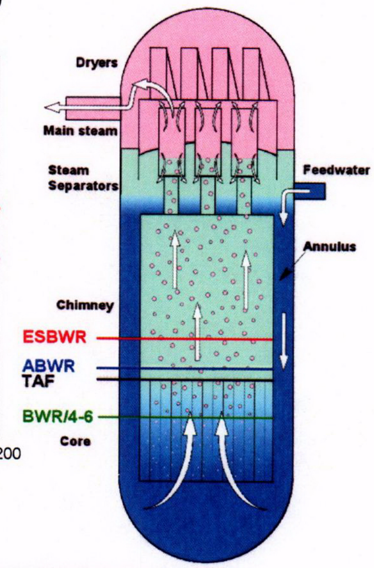
RPV Inventory Distribution Immediately following a LOCA

c06

Water Level in Shroud Following a Typical Pipe Break

(values are intended to show typical trends for limiting breaks)





ESBWR Margins are Increased Over Past Plants

ESBWR Program Summary and Conclusion

- **15+ year technology and design program**
  - a BWR with less components
- **Simplification and margins by design**
  - large vessel results in benign response
  - analysis is simplified
- **Challenges for the coming months**
  - need approval of TRACG for ESBWR analyses
  - confirmation that regulatory risk is manageable

GE Nuclear Energy

ESBWR TRACG Approval Process

Bob Gamble
Manager, ESBWR, GENE
GE Energy, USA

ACRS Thermal Hydraulics Sub-committee Meeting
Jan 15, 2004,
Rockville, Maryland

Outline

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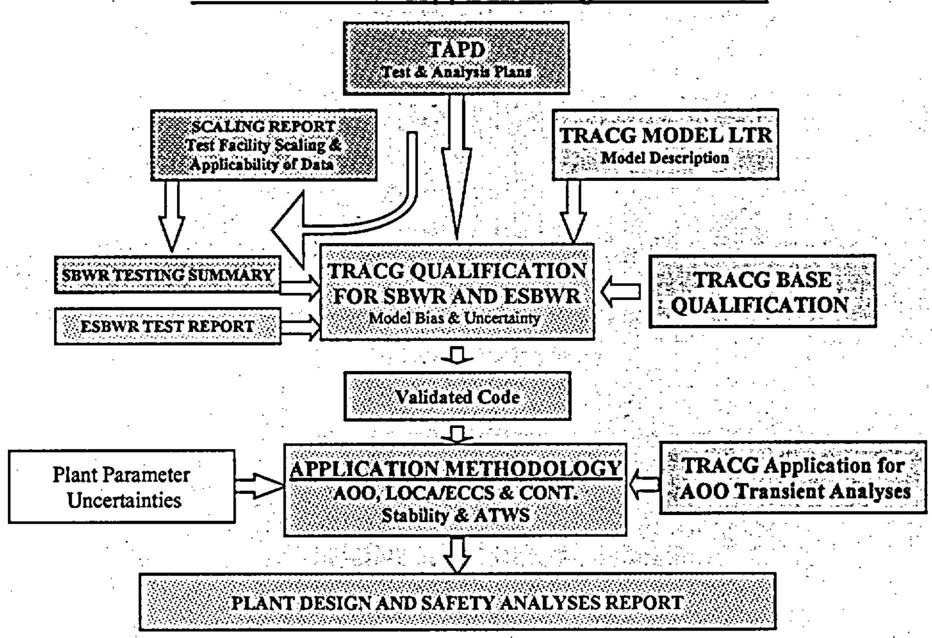
Table 2.1- 1. CODE SCALING, APPLICABILITY AND UNCERTAINTY EVALUATION METHODOLOGY

CSAU Step	Description
1	Scenario Specification
2	Nuclear Power Plant Selection
3	Phenomena Identification and Ranking
4	Frozen Code Version Selection
5	Code Documentation
6	Determination of Code Applicability
7	Establishment of Assessment Matrix
8	Nuclear Power Plant Nodalization Definition
9	Definition of Code and Experimental Accuracy
10	Determination of Effect of Scale
11	Determination of the Effect of Reactor Input Parameters and State
12	Performance of Nuclear Power Plant Sensitivity Calculations
13	Determination of Combined Bias and Uncertainty
14	Determination of Total Uncertainty

CSAU Process Followed

ESBWR Methods Approval Program Elements



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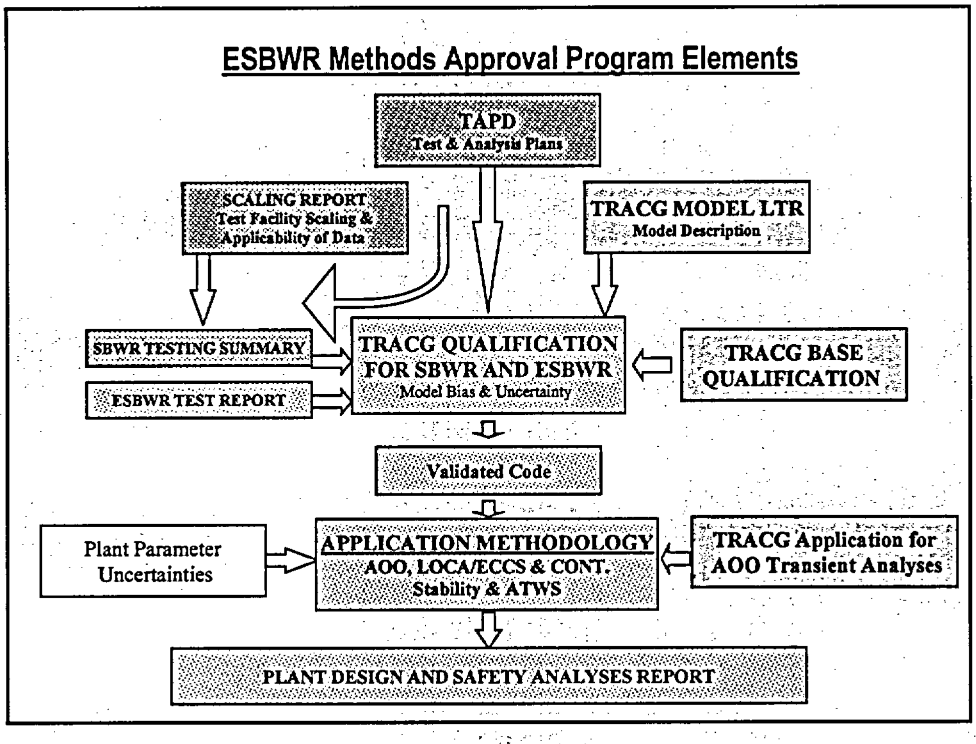
ESBWR Methods Approval Program Elements
TAPD
Test & Analysis Plans
SCALING REPORT
Test Facility Scaling & Applicability of Data
TRACG MODEL LTR
Model Description
SBWR TESTING SUMMARY
ESBWR TEST REPORT
TRACG QUALIFICATION FOR SBWR AND ESBWR
Model Bias & Uncertainty
TRACG BASE QUALIFICATION
Validated Code
Plant Parameter Uncertainties
APPLICATION METHODOLOGY
AOO, LOCA/ECCS & CONT.
Stability & ATWS
TRACG Application for AOO Transient Analyses
PLANT DESIGN AND SAFETY ANALYSES REPORT

GE Nuclear Energy

ESBWR Test Program Overview

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GE Proprietary

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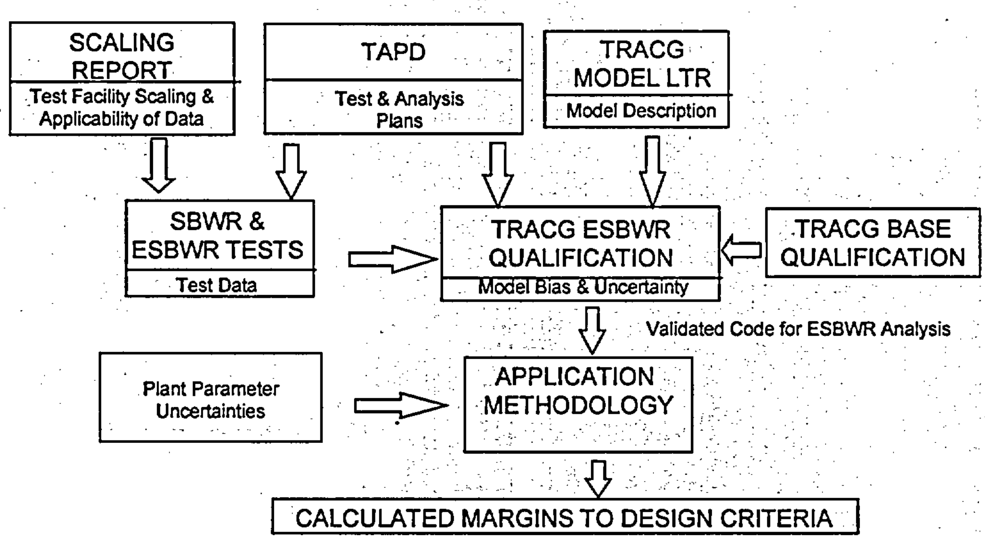
TRACG Applicability for ESBWR LOCA Analysis

ACRS T H Subcommittee Meeting
Closed Session
January 15, 2004

Bharat Shiralkar

ESBWR Technology Program Elements



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TRACG Applicability for ESBWR LOCA Analysis

- *Systematic Evaluation of Important Phenomena (PIRT)*
- *Important parameters used to evaluate:*
  - *TRACG Model Capabilities*
  - *TRACG Assessment needs*
  - *Sensitivities to figure of merit*
- *Provides basis for conclusions on applicability of TRACG*

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Important Phenomena for Calculation of Chimney Water Level

Parameter	*TRACG Model*	*Assessment*
Interfacial shear in core (fuel bundle)	*Realistic*	*FRIGG bundle data*
Interfacial shear in chimney	*Realistic*	*Ontario Hydro, EBWR*
Interfacial shear in LP/Downcomer	*Realistic*	*Bartolomei, Wilson*
Critical flow	*Realistic*	*Marviken, PSTF*
Chimney level	*Integral calculation*	*GIRAFFE/SIT, GIST*

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Important Phenomena for Calculation of Long Term Containment Pressure

Parameter	*TRACG Model*	*Assessment*
PCC heat transfer	*Realistic*	*PANTHERS, PANDA*
Non-condensible transport to wetwell	*Conservative*	*PANDA, parametric studies*
Suppression pool stratification	*Conservative*	*PSTF*
Containment pressure	*Integral calculation*	*PANDA*

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Quantitative Assessment of TRACG

- *Assessment accuracy (error) compiled for all comparisons*
- *Adequacy established by comparing against:*
  - *Experimental uncertainty*
  - *Design margin*
  - *Engineering judgment*
- *Examples in following charts*

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Calculations performed for LOCA/ECCS

	Minimum Static Head inside Chimney, m		
Single Failure → / Break ↓	1 DPV	1 SRV	1 GDCS Injection Valve
Main Steam Line	3.08	3.01	3.18
GDCS Line	2.43	2.43	2.36
Bottom Drain Line	2.68	2.67	2.64

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Calculations performed for LOCA/Containment

Break location	Single Failure
Main Steam Line	1DPV
Bottom Drain Line	1DPV

1/15/04 BSS-21

Conclusion

- TRACG is applicable for ESBWR LOCA analysis and should be approved for design certification analysis in conjunction with defined application methodology

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