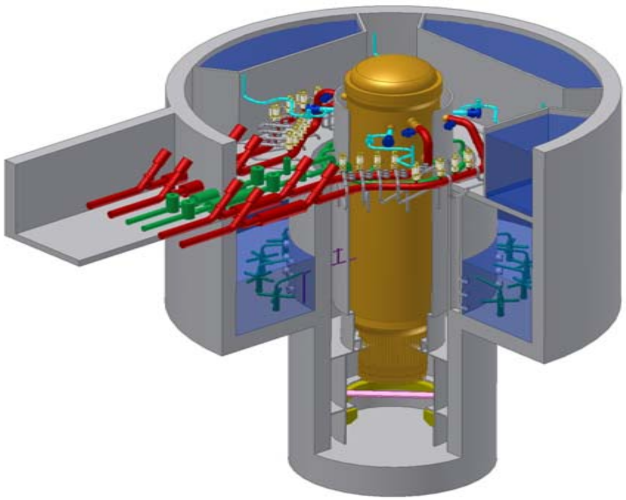
Presentation to
Nuclear Regulatory Commission



Summary
ESBWR Design Control Document, Tier 2
Chapter 3
Design of Structures, Components, Equipment and Systems

September 27, 2005

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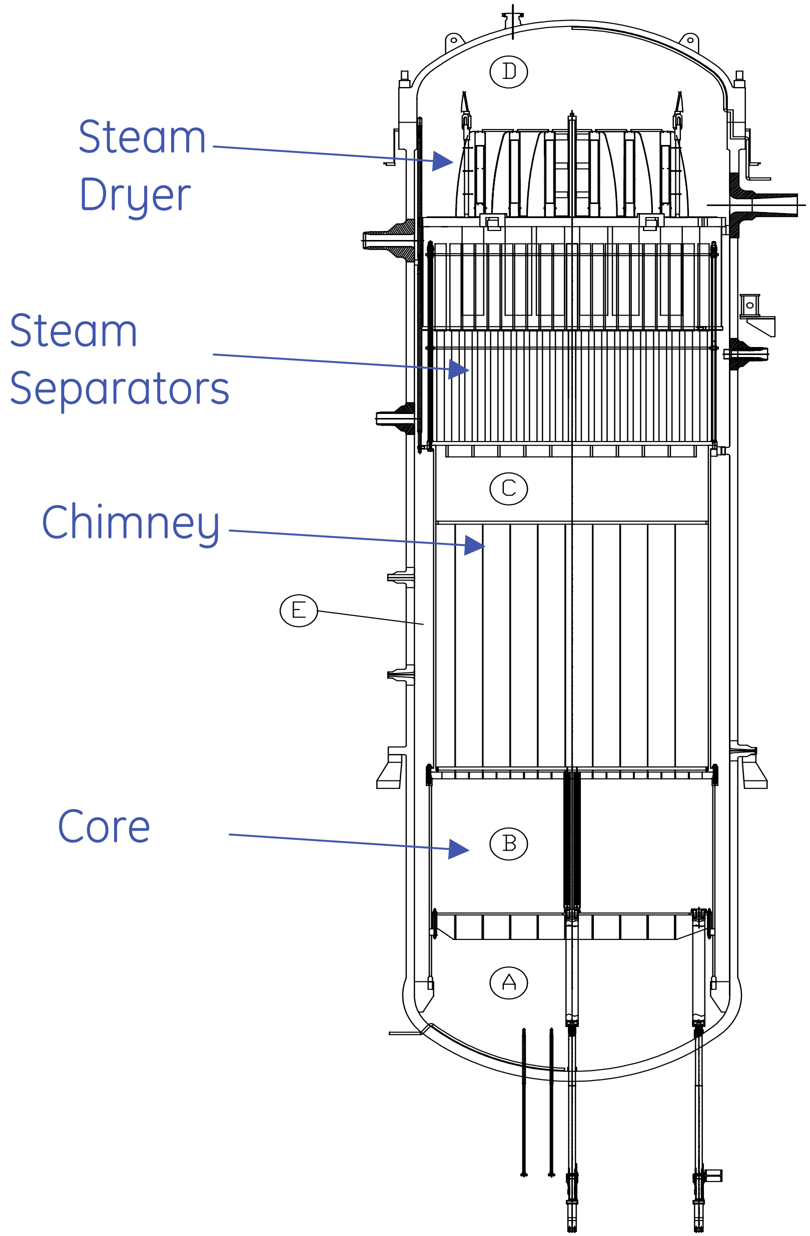

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ESBWR RPV & Internals - New Features

- Chimney with Partitions
- Shroud Supported by 12 Bracket Supports from RPV
- Upper Support at Top of Chimney
- Reactor Vessel Supported by 8 Sliding Supports
- Four Drain Lines (enter RPV outside of CRD pattern)
- Standby Liquid Control Lines are Routed from Above the Core and Penetrate the Shroud
- Chimney Head is a Flat Plate

Table 3.9-2

Load Combinations and Acceptance Criteria for Safety-Related, ASME Code Class 1, 2 and 3 Components, Component Supports, and Class CS Structures

Plant Event	Service Loading Combination [(1), (2), (3)]	ASME Service Level [(4)]
1. Normal Operation (NO)	N	A
2. Plant/System Operating Transients (SOT)	(a) N + TSV	B
	(b) N + SRV[(5)]	B
3. NO + SSE	N + SSE	B[(12), (13)]
4. Infrequent Operating Transient (IOT), ATWS, DPV	(a) N[(6)] + SRV[(5)]	C [(14)]
	(b) N + DPV[(7)]	C[(14)]
5. SBL	N + SRV[(8)] + SBL[(9)]	C[(14)]
6. SBL or IBL + SSE	N + SBL (or IBL)[(9)] + SSE + SRV[(8)]	D[(10), (14)]
7. LBL + SSE	N + LBL[(9)] + SSE	D[(10), (14)]
8. NLF	N + SRV[(5)] + TSV[(11)]	D[(14)]

Load Combinations and Acceptance Criteria for Class 1 Piping Systems

Condition	Load Combination for all terms(1) (2)	Acceptance Criteria
Design	PD + WT	Eq 9 $\leq$ 1.5 S_m NB-3652
Service Level A & B	PP, TE, ΔT1, ΔT2 , TA-TB, RV_1, RV_2I, RV_2D, TSV, SSEI, SSED	Fatigue - NB-3653: Eq 12 & 13 $\leq$ 3.0 S_m U < 1.0
Service Level B	PP + WT + (TSV) PP + WT + (RV_1) PP + WT + (RV_2I)	Eq 9 $\leq$ 1.8 S_m, but not greater than 1.5 S_y Pressure not to exceed 1.1P_a (NB-3654)
Service Level C	PP + WT + $[(CHUGI)^2 + (RV_1)^2]^{1/2}$ PP + WT + $[(CHUGI)^2 + (RV_2I)^2]^{1/2}$	Eq 9 $\leq$2.25 S_m, but not greater than 1.8 S_y Pressure not to exceed 1.5 P_a (NB-3654)
Service Level D	PP + WT + $[(SSEI)^2 + (TSV)^2]^{1/2}$ PP + WT + $[(SSEI)^2 + (CHUGI)^2 + (RV_1)^2]^{1/2}$ PP + WT + $[(SSEI)^2 + (CHUGI)^2 + (RV_2I)^2]^{1/2}$ PP + WT + $[(SSEI)^2 + (CONDI)^2 + (RV_1)^2]^{1/2}$ PP + WT + $[(SSEI)^2 + (CONDI)^2 + (RV_2I)^2]^{1/2}$ PP + WT + $[(SSEI)^2 + (API)^2]^{1/2}$	Eq 9 $\leq$ 3.0 S_m but not greater than 2.0 S_y Pressure not to exceed 2.0 P_a (NB-3654)

Piping Analysis Completed to Support ESBWR Design Certification

- ASME Code Thermal Analysis (heatup and transients including thermal stratification) for the Following Piping inside Containment:
  - Main Steam Lines (28”) Including SRV Discharge Lines (10”)
  - Feedwater (12” & 22”)
  - Reactor Water Cleanup/Shutdown Cooling Line (12”)
  - Isolation Condenser Line from RPV to Isolation Condenser (14” & 18”)

  Criteria that was Met:
  - < 0.80 x ASME Code limit for Eq. 12
  - Fatigue Usage < 0.10
- Erosion/Corrosion Evaluation of Feedwater and Main Steam Piping

Lungmen Project - Containment Piping Experience

Lungmen Line #	System	Eq 12 Max Stress Ratio (Thermal)	Eq 13 Max Stress Ratio (Dynamic)	Eq 14 Max Fatique
B21-2501A	Main Steam	0.70	0.46	0.079
B21-2502A	Main Steam	0.60	0.50	0.068
B21-2503A	Main Steam	0.54	0.50	0.076
B21-2504A	Main Steam	0.75	0.49	0.099
N22-2501	Feedwater	0.79	0.61	0.085
N22-2502	Feedwater	0.79	0.63	0.085
E11-2501	RHR	0.54	0.53	0.074
E11-2502	RHR	0.78	0.75	0.077
E22-2501	High Pressure Core Flooder	0.60	0.45	0.079

Lungmen Seismic Ground Acceleration = .4 g

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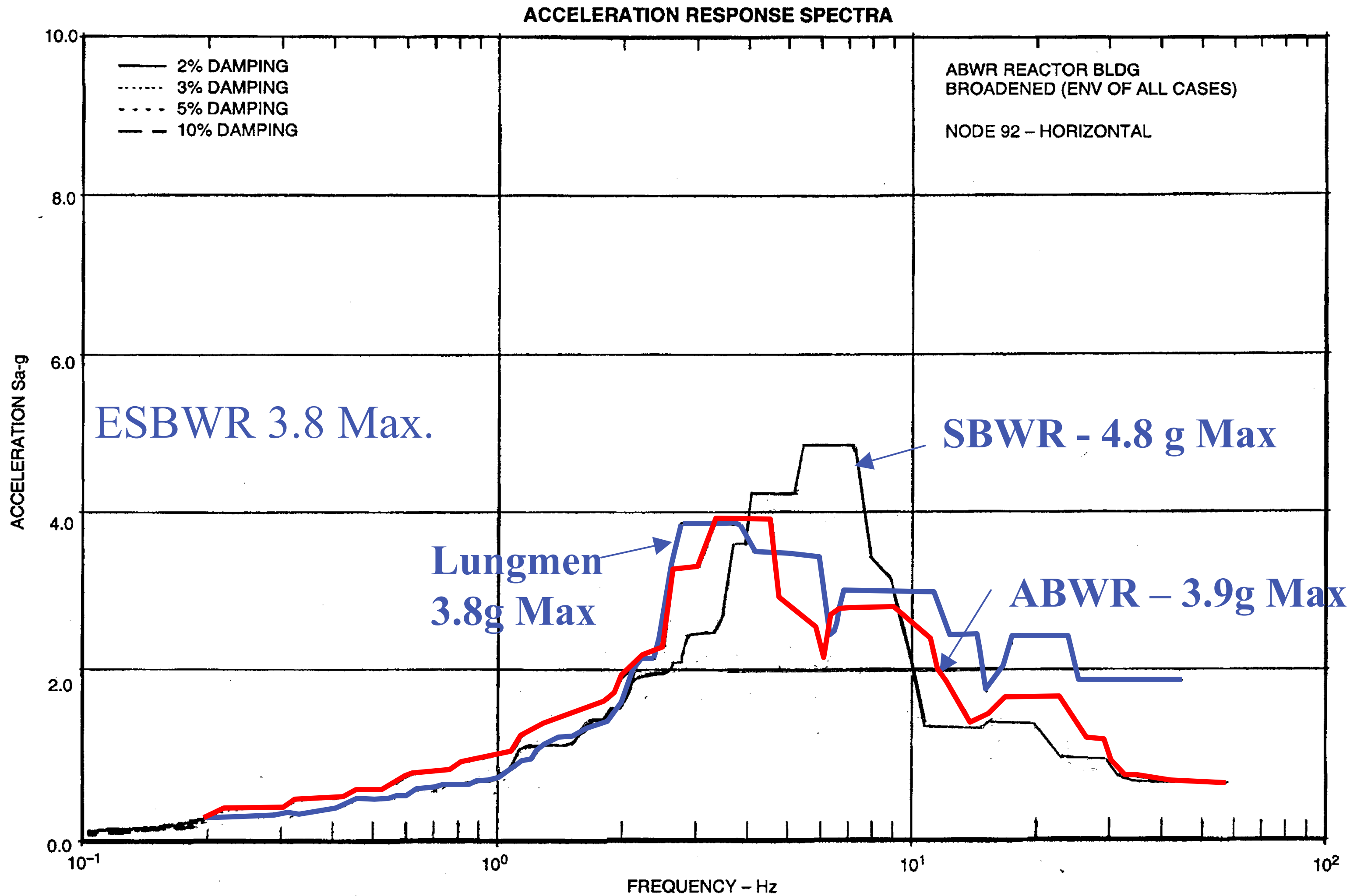
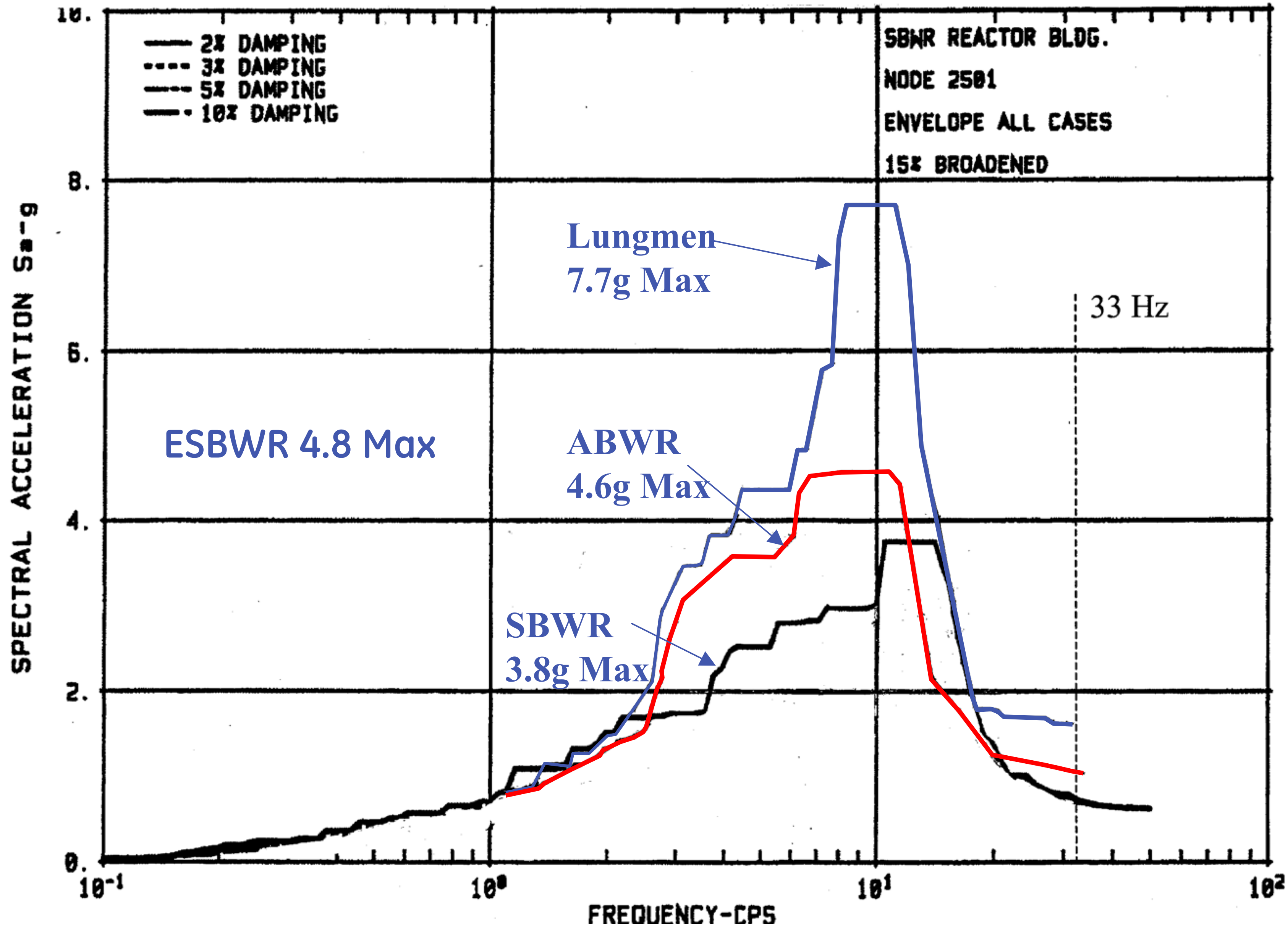
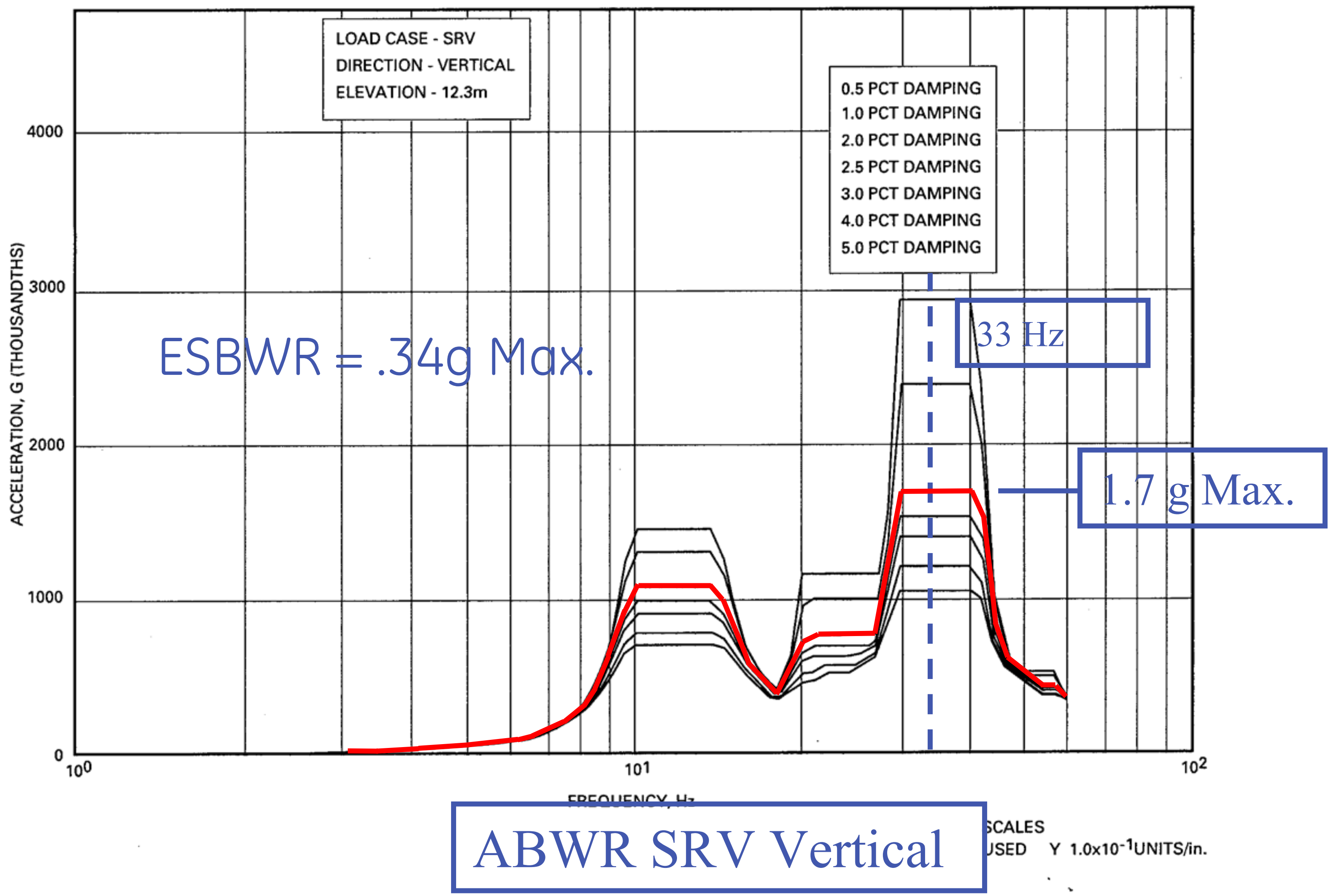
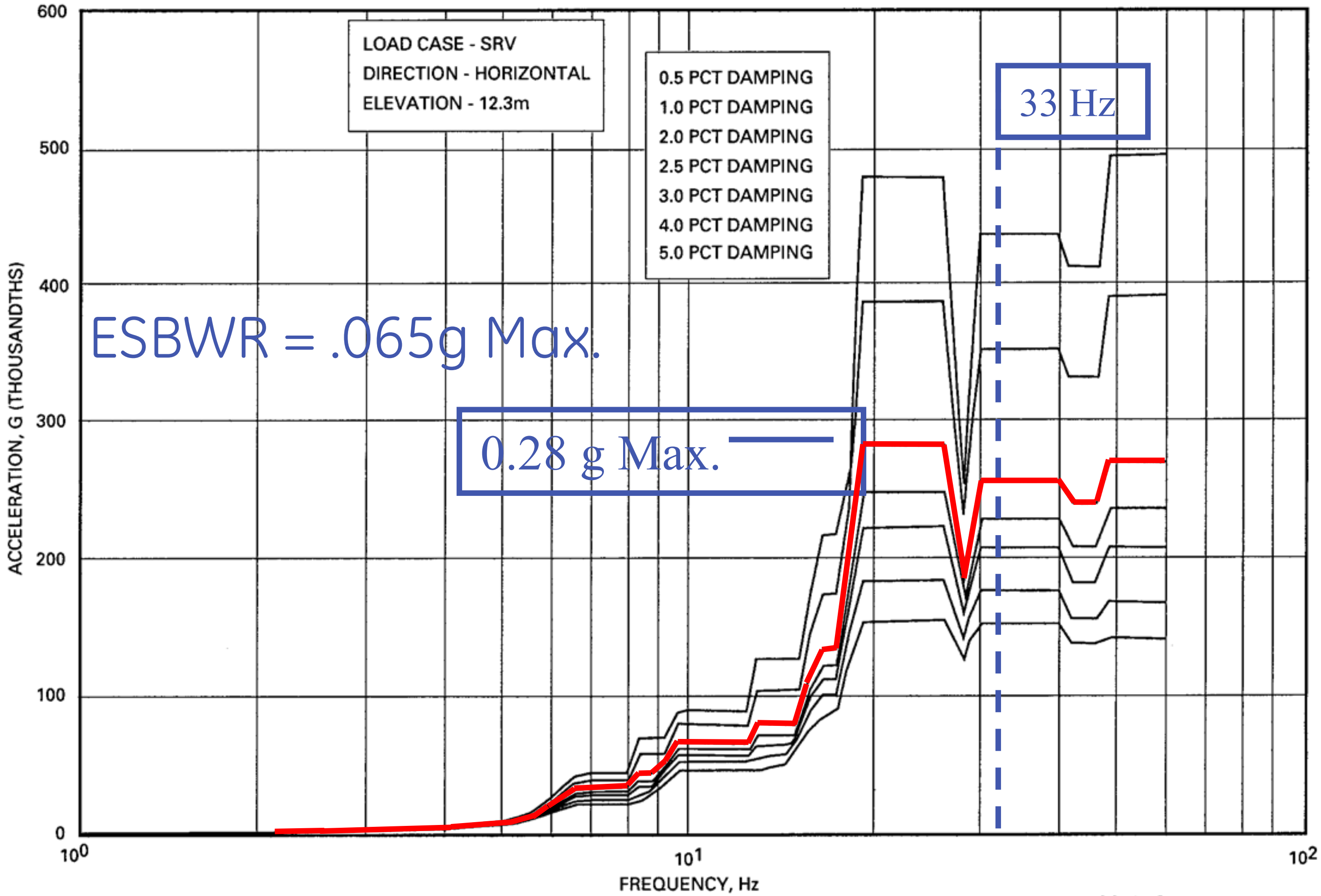


SSE Horizontal Comparison



SSE Vertical Comparison


LOAD CASE - SRV
DIRECTION - VERTICAL
ELEVATION - 12.3m
0.5 PCT DAMPING
1.0 PCT DAMPING
2.0 PCT DAMPING
2.5 PCT DAMPING
3.0 PCT DAMPING
4.0 PCT DAMPING
5.0 PCT DAMPING
ACCELERATION, G (THOUSANDTHS)
4000
3000
2000
1000
0
10^0
10^1
10^2
FREQUENCY, Hz
33 Hz
ESBWR = .34g Max.
1.7 g Max.
SCALES
USED Y $1.0x10^{-1}$UNITS/in.
ABWR SRV Vertical



ABWR SRV Horizontal

Actions Related to Piping Analysis

- Next Revision of DCD will be Updated to Reflect Current Plan and Tasks Completed
- Proceed to do Complete Analysis of Class 1 Piping Starting with the Main Steam Lines Inside containment
- This will be Followed by Feedwater Piping Inside Containment
- Main Steam will be Completed by April 06

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Reactor Internals Vibration Program

- Perform modal analysis of major components to establish vibration modes and frequencies
- Assemble data from previous plant vibration measurements to identify predominant vibration response modes
- Identify parameters expected to influence vibration response amplitudes
- Establish correlation functions for the variable Parameters
- Establish vibration amplitudes, and obtain the predicted mode and frequency from the the dynamic modal analysis
- The dynamic modal analysis results determine the type and location of sensors, and forms the basis for interpreting startup test results

RPV Internals FIV Initial Review

- The Design of the Internals are Very Similar to Previous Plants
- The Chimney Partitions Need Early Evaluation Bases on Geometry and Require Additional Evaluation Methods
- Steam Dryer Requires Additional Process Methods Based on Operating Plant Experience

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Status of Chimney FIV Evaluation

- Evaluation has been Completed using Scale Tests and Two-Phase flow Analysis
- The following Influences were Investigated:
  - Scale (size) Effect
  - Inlet Mixing Conditions of Gas and Liquid
  - Elevation
  - Properties
- Testing included 1/6th and 1/12th Scale Models of a Single Cell

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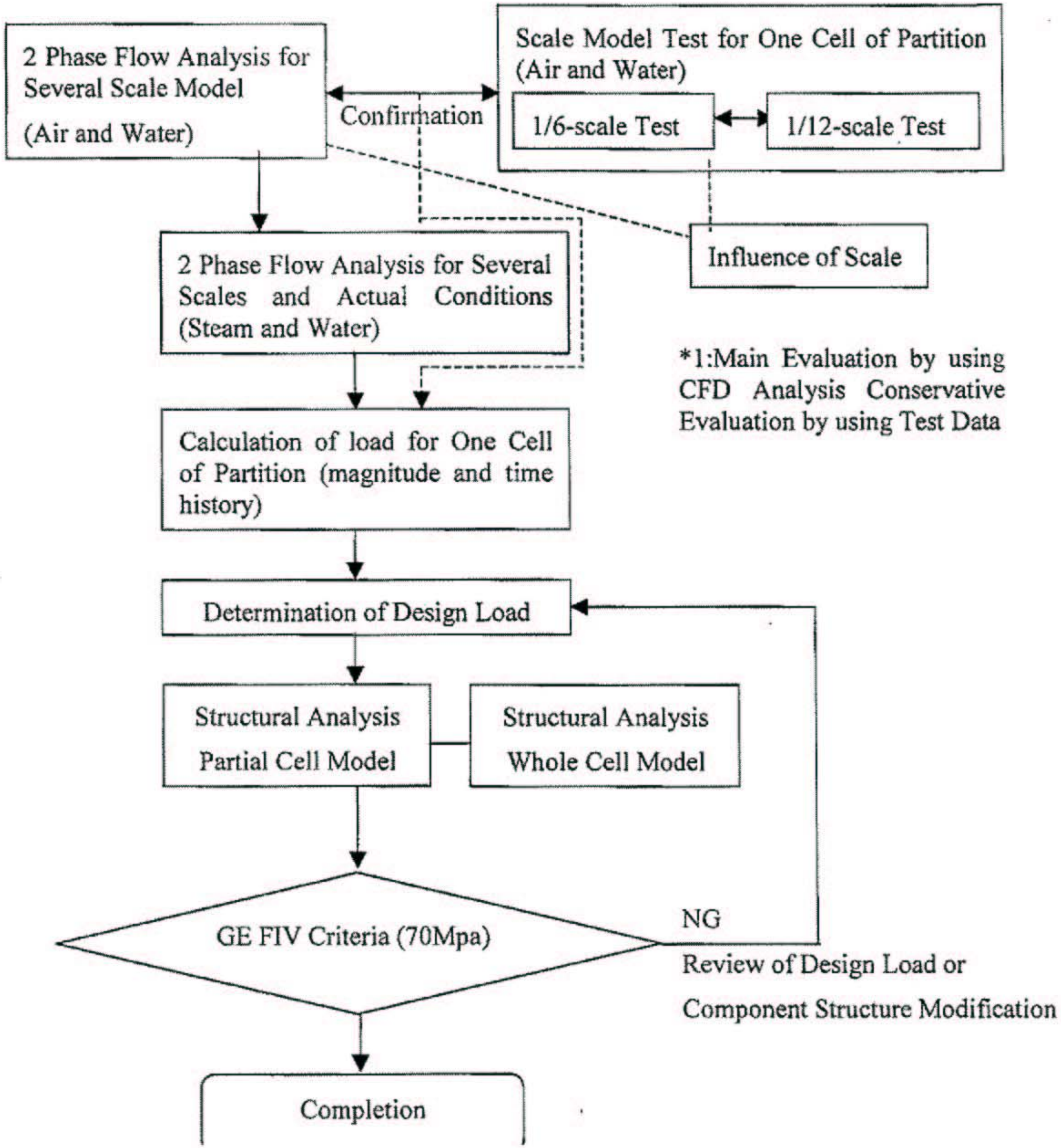

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Flow Chart for Chimney FIV Evaluation

Results of Scale Tests & CFD Analysis

- Amplitude of Pressure fluctuations was Decreased with Increasing Scale
- Influence of Inlet Mixing conditions was relatively Small
- Pressure Fluctuation was Largest at the Top
- Peak Frequency of Pressure Fluctuation was ~2 Hz
- Maximum Peak to Peak Pressure fluctuation was ~ 15 kPa

Results of Analytical Model

- Lowest Eigenvalue of the Structure is 56.6 Hz
- Maximum Stress Value near the Edge of the Plate was 41 MPa Vs. 70 MPa Limit for Stainless Steel

Completed Steam Dryer Evaluation

- Flow and Acoustic Pressure Analysis was performed for the Steam Dome Region
- Both ABWR and ESBWR were Modeled to do a comparative Evaluation
- ESBWR has More Steam Flow but More Space in the RPV Dome than ABWR
- For ESBWR the Dryer Configuration Assumed was the Same as ABWR Except for the Increased Diameter of the Support Ring & Skirt

Results of Analysis

Flow Analysis

- CFD analysis Found that:

- The Turbulent Energy and Vorticity Around the ESBWR Dryer Hood was Equal to or Smaller than ABWR

-Fluctuating Fluid Force Acting on the ESBWR Dryer was Estimated to be Smaller than ABWR

Acoustic Analysis

- The Resonant Characteristics were Essentially the same for Both Dryers
- The Fundamental Acoustic Resonance Modes ~40 Hz

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GE Actions Related to FIV

- Provide Evaluation Plan for Steam Dryer
- Provide a Topical Report on the Chimney Partition Evaluation
- Provide a Topical Report on Initial Evaluation of Reactor Internals with Regard to FIV

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Motor Operated Valve Standards

- DCD Rev 0 did not include Generic Letter 96-05
- DCD Rev 1 will make the following Changes:
  - In 3.9.6.1, the topic of Motor Operated Valves will be expanded to include all Power Operated Valves, and will address the frequency of operability testing per GL 96-05
  - Power Operated Valves listed in Table 3.9-8 will be changed to include GL 96-05 testing requirements
- New Standards will be incorporated into DCD when they are approved for use by the NRC