January 22, 2001

LICENSEE: STP Nuclear Operating Company

FACILITY: South Texas Project, Units 1 and 2

SUBJECT: MEETING SUMMARY - MEETING WITH STP NUCLEAR OPERATING COMPANY TO DISCUSS THE PROPOSED 3-VOLT ALTERNATE REPAIR CRITERIA FOR SOUTH TEXAS PROJECT, UNIT 2, STEAM GENERATORS (TAC NO. MA8271)

On November 17, 2000, the U.S. Nuclear Regulatory Commission (NRC) and STP Nuclear Operating Company (STPNOC) met at the NRC offices in Rockville, Maryland, to discuss the issues identified in the staff's request for additional information (RAI) issued on October 31, 2000, related to STPNOC's request for license amendment which proposes to revise the South Texas Project, Unit 2, steam generator alternate repair criteria from 1-volt to 3-volt. The purpose of the meeting was to facilitate communication between the staff and the licensee to allow the effective resolution of the technical issues identified in the RAI. These issues were centered around the question of adequacy regarding the licensee's analytical methodology used to model the steam generator behavior, including the tubes and the tube support plates, during a main steam line break accident.

Enclosure 1 provides a list of attendees at the meeting. During the meeting, the licensee presented its responses to the staff's RAI. Enclosure 2 provides a copy of the slides used by the licensee.

At the conclusion of the meeting, the staff stated that it will provide the licensee with a feedback on the information presented during the meeting within several days. Overall, the meeting with the licensee was productive in clarifying the technical issues.

/RA/

Tae Kim, Senior Project Manager, Section 1
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-499

Enclosures: 1. List of Attendees
2. Licensee Handout

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ACCESSION NUMBER: ML00

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 22, 2001

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LIST OF ATTENDEES
November 17, 2000
MEETING BETWEEN NRC AND STPNOC
3-volt Alternate Repair Criteria

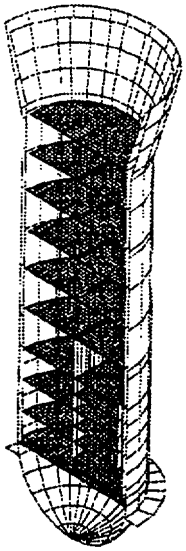
NAME	TITLE/POSITION	ORGANIZATION
Bob Gramm	Section Chief	NRR/DLPM/PDIV-1
T. J. Kim	Project Manager	NRR/DLPM/PDIV-1
F. Akstulewicz	Section Chief	NRR/DSSA/SRXB
Ted Sullivan	Section Chief	NRR/DE/EMCB
Warren Lyon	Sr. Reactor Engineer	NRR/DSSA/SRXB
Ralph Landry	Sr. Reactor Engineer	NRR/DSSA/SRXB
Joe Staudenmeier	Reactor Engineer	NRR/DSSA/SRXB
Robert Spence	Reactor Engineer	RES/DSARE/REAHFB
Norm Lauben	Reactor Engineer	RES/DSARE/SMSAB
Joe Hopenfeld	Reactor Engineer	RES/DSARE/ERAB
Len Ward	NRC Contractor	ISL, Inc.
Mark McBurnett	Director, Quality & Licensing	STPNOC
Mark Kanavos	SG Replacement Project Manager	STPNOC
Chet McIntyre	SG Projects	STPNOC
Bob Keating	Contractor for STPNOC	Westinghouse
Hermann Lagally	Contractor for STPNOC	Westinghouse
Hans Giesecke	Contractor for STPNOC	MPR Associates
Tom Pitterle	Contractor for STPNOC	E-Mech Technology
David Lochbaum	Nuclear Safety Engineer	Union of Concerned Scientists

Enclosure 1

South Texas Unit 2 – 3Volt ARC

Technical Discussion on NRC RAI

November 17, 2000



South Texas Project 3-Volt Alternate Repair Criteria

2RE08 (March 2001) SG Inspection Plan

- Identify leaking tubes by secondary-to-primary pressure test
- Determine morphology of leaking defects
- 100% bobbin coil inspection
- RPC examine and plug all DSIs > 3 Volts

2RE08 SG Inspection Plan - Cont.

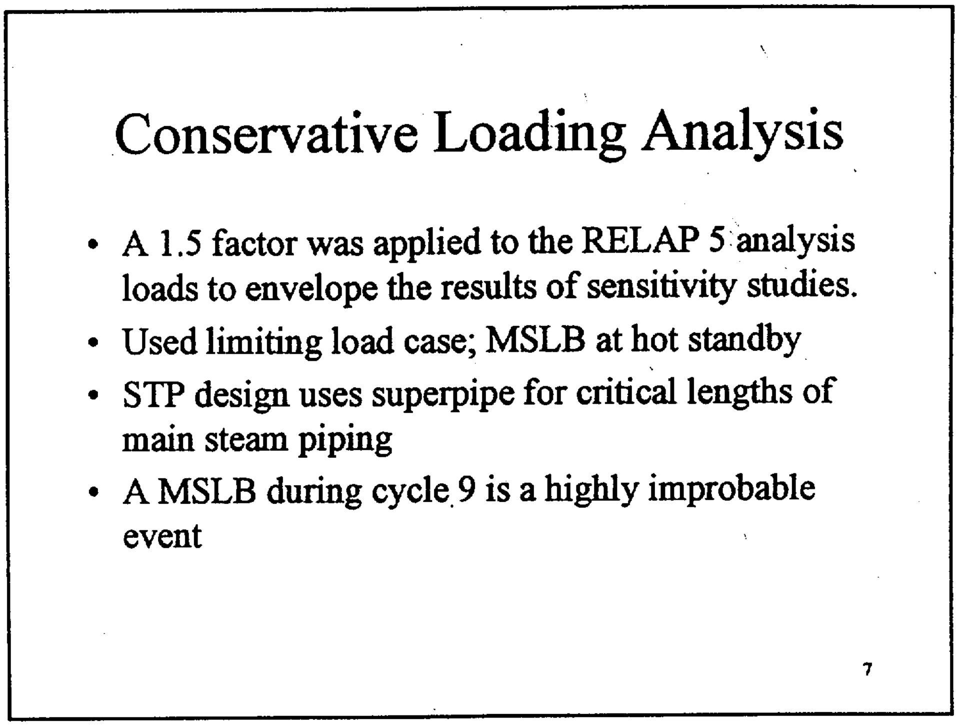
- RPC examine all DSIs between 1 and 3 Volts and preventively plug based on known morphology
- RPC examine all DSIs between 0.75 Volts and 1 Volt with > 0.75 Volt/cycle growth and preventively plug based on known morphology
- Leave no marginal tubes in service

DSIs at TSPs Intersections Restrained From Burst.

- Industry and STP experience (4000+ DSIs) show that axial cracks contained within TSPs intersections do not propagate throughwall outside of the TSPs.
- Lab testing has shown that cracks with up to 3/8 inch of exposure beyond the TSP behave like restrained from burst cracks.

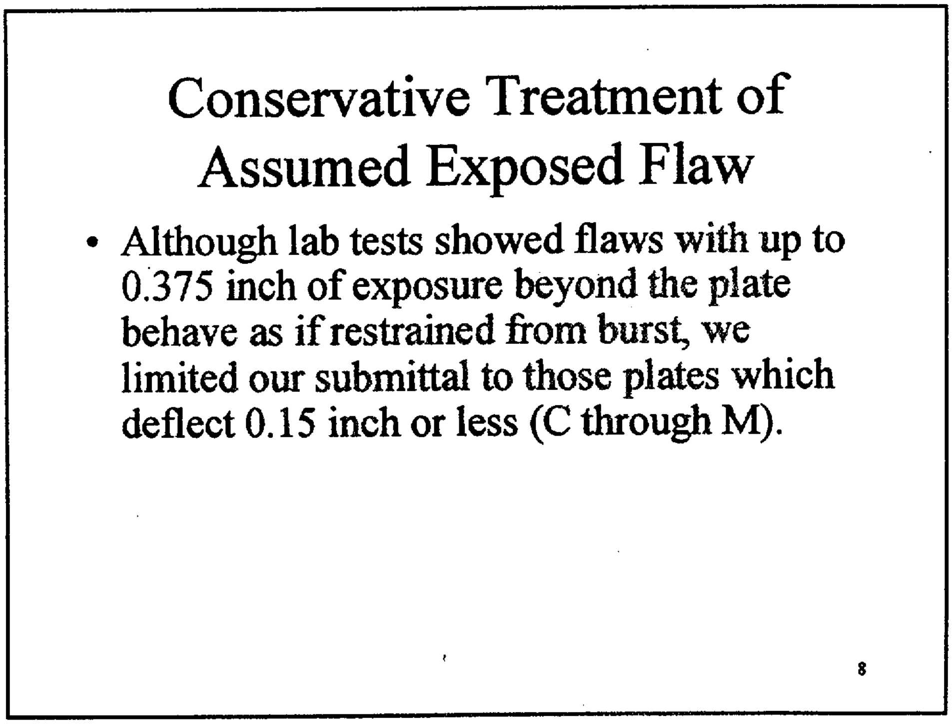
DSIs at TSPs are Restrained From Burst - Cont.

- Through our analysis, we have shown that during the limiting DBA (SLB), TSPs deflect less than 3/8 inch.
- Therefore, DSIs left in service are restrained from burst



Conservative Loading Analysis

- A 1.5 factor was applied to the RELAP 5 analysis loads to envelope the results of sensitivity studies.
- Used limiting load case; MSLB at hot standby
- STP design uses superpipe for critical lengths of main steam piping
- A MSLB during cycle 9 is a highly improbable event



Conservative Treatment of Assumed Exposed Flaw

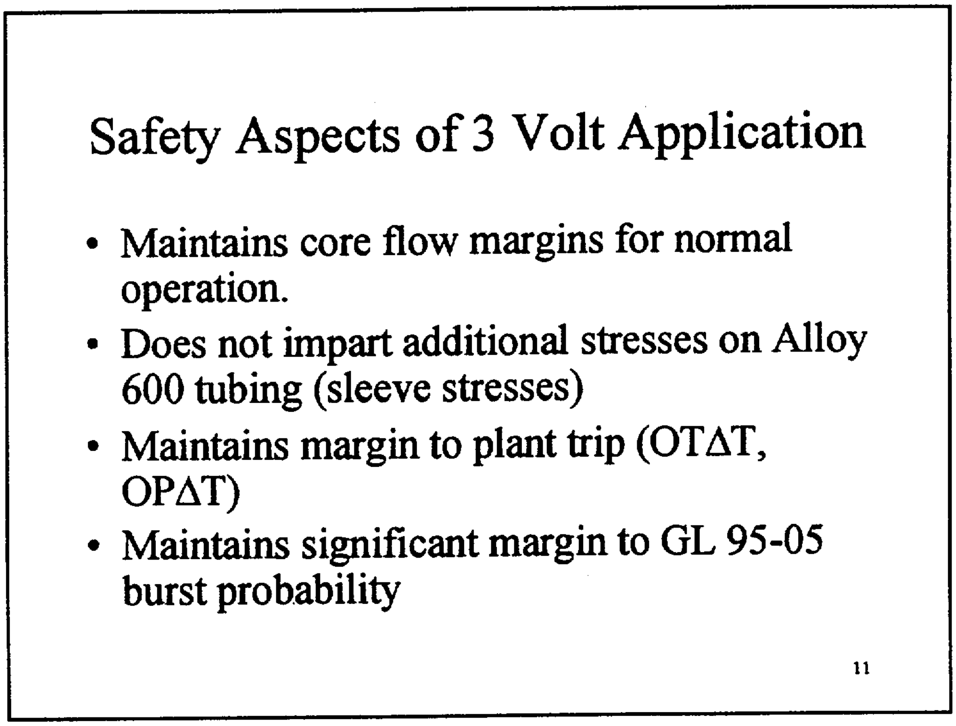
- Although lab tests showed flaws with up to 0.375 inch of exposure beyond the plate behave as if restrained from burst, we limited our submittal to those plates which deflect 0.15 inch or less (C through M).

Conservative Location and Population assumptions

- Probability of burst projection assumes every hot leg TSP/tube intersection (43,659) is cracked throughwall the full length of the support plate and every flaw is exposed by 0.15 inch during SLB.
- This creates an infinitesimally small burst probability ($<<10^{-5}$) as compared to the allowable limits of Generic Letter 95-05 (10^{-2}).

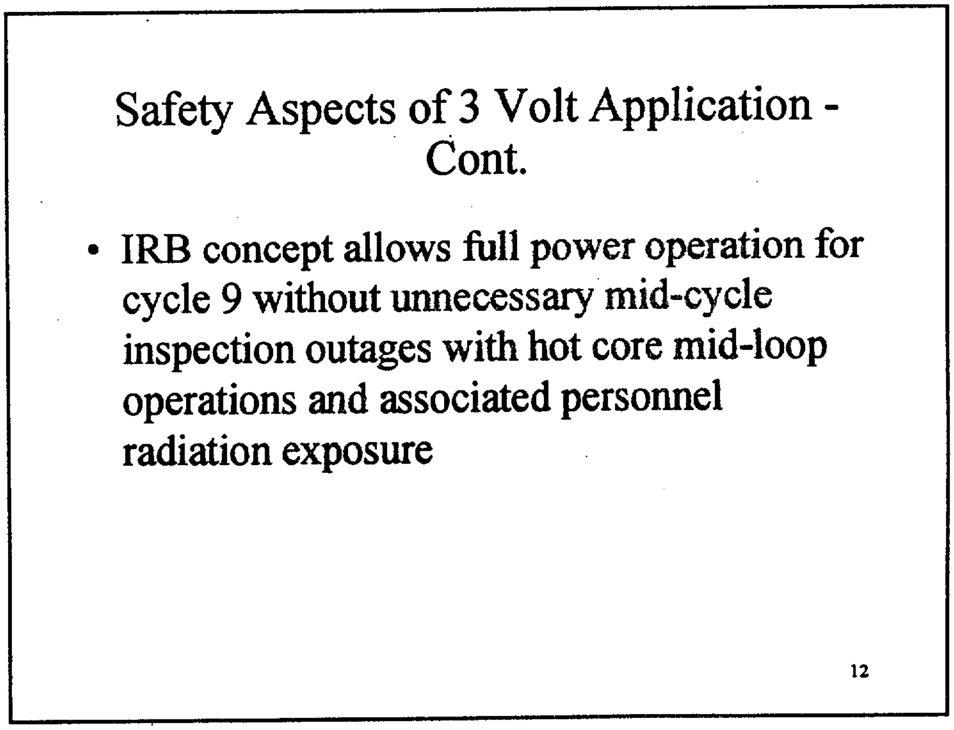
Conservative Voltage Repair Criteria

- Our analysis supports a full ARC repair limit of 17 volts and higher for hot leg intersections in TSPs C-M without physical modification to the SGs
- Doel 4 and Tihange 3 (Model E SGs) allowed 10 Volt DSIs to remain in service for several cycles
- A 3 Volt repair limit is proposed for STP unit 2 for cycle 9 only



Safety Aspects of 3 Volt Application

- Maintains core flow margins for normal operation.
- Does not impart additional stresses on Alloy 600 tubing (sleeve stresses)
- Maintains margin to plant trip (OTΔT, OPΔT)
- Maintains significant margin to GL 95-05 burst probability



Safety Aspects of 3 Volt Application - Cont.

- IRB concept allows full power operation for cycle 9 without unnecessary mid-cycle inspection outages with hot core mid-loop operations and associated personnel radiation exposure

Financial Aspects of 3 Volt Application

- $3.5 million exposure due to unnecessary tube plugging in 2RE08 (March 2001)
- $7 - 10 million exposure per outage due to unnecessary mid-cycle inspections on SGs that will be replaced in Fall, 2002

Question 2 (STP-2; RAI 10/31/2000; Docket No. 50-499)

Please justify use of RELAP-5 for this application (1) by contrasting/comparing the RELAP-5 fluid dynamic models with the phenomena that occur within the SG during an MSLB and (2) by applicable comparisons to experimental data. If you reference data for scaled facilities or conditions such as non-full flow MSLB rates, then please provide suitable justification for the scaling applicability. Your response should establish why RELAP-5 is applicable and why it is not necessary to use a verified, multi-dimensional, two-phase, transient, fluid dynamics code linked to the response of the mechanical components to support your request.

Please justify the applicability of the referenced test facility to determination of TSP loss coefficients. Also address the adequacy of your Figure 4-4 comparison of a correlation with data when the loss coefficient of interest appears to be outside the range of the data.

How does RELAP-5 provide tube and TSP loadings and vibration in the axial cross-tube flow pattern areas of the preheater and flow distribution baffle (FDB) regions? Please address, for example, the non-uniformity of the loading under cross-flow conditions and how this is addressed in your analysis.

How are horizontal tube loadings addressed and how do such loadings affect relative tube/TSP movement? How are vertical tube loadings addressed in the U-bend regions.

Experience shows that a venturi operating with choked flow may cause significant hydraulic loads and pipe movement. How have you addressed such phenomena for the SG exit venturi? If you believe RELAP-5 will predict this behavior, please provide substantiation.

Please address the adequacy of fluid noding with respect to local void generation and local void/liquid slugs throughout the SG internals. Include propagation/movement through the SG structure, generation of local loads as a result of generation/movement, translation of these loads into mechanical movement, and feedback of this mechanical movement into the fluid behavior. Include a discussion of the applicability of RELAP-5 to analysis of this behavior for normal operation, during upset conditions, and under accident conditions. (Note your sensitivity calculation with radial nodes near the top of the SG may not be sufficient to address the local fluid aspects of this question because (1) RELAP-5 has not been shown to apply and (2) the maximum calculated TSP deflection and maximum cross flow rates do not occur in the region of your sensitivity calculation.)

Model E Steam Generator Tube Support Plate Deflections Under Steam Line Break Conditions

Use of RELAP5

Thermal Hydraulic Analysis

Verification of RELAP5

- Independent code assessment and review efforts conducted by NRC include comparison to a large amount of testing and plant data
- For blowdown conditions, results generally indicate good agreement with pressures and water levels, particularly during the early part of the transient

Geometry of Steam Generator

- Flow Restrictor in Nozzle
- Upper Steam Separators
- Swirl Vane Separators
- Deck Plate
- Wrapper Forming Downcomer
- Tube Support Plates

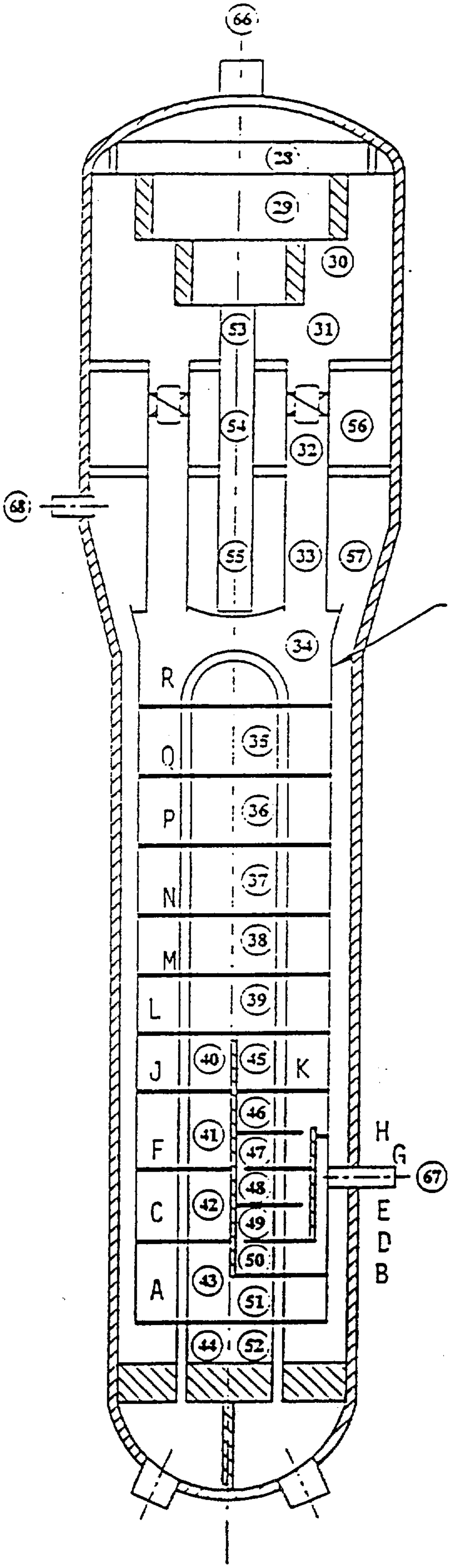


Figure 3-1. Schematic of Model E Steam Generator

Comparative Flow Areas

- Nozzle Restrictor - 1.4 Sq Ft
- Inside Nozzle - 107.7 Sq Ft
- Between Separators - 193.2 Sq Ft
- Tube Bundle Between TSP's - 68.62 Sq Ft
- Through TSP's (Typical) - 19.1 Sq Ft
- Downcomer - 9.8 Sq Ft
- Downcomer Windows - 9.8 Sq Ft

1-D Characterization of Model E Steam Generator

- The Model E SG can be modeled as a series of volumes and flow connectors, similar to the tanks and flow restrictors for which there is extensive RELAP5 experience
- The equivalent 1-D parameters chosen to characterize the Model E SG are verified based on steady state test and operating plant data

1-D Characterization of Model E Steam Generator

- In the region of principal interest, on the hot leg side of the preheater divider plate, there are no significant cross-flow influences; thus the flow will be reasonably uniform in the axial direction

Potential 2-D Effects

- Some cross-flow may occur above the preheater due to relative density differences
- Sensitivity analyses were performed and demonstrate that radial flow effects within the bundle above the preheater are small
- Cross-flow across the bottom of the tube bundle is included in Model E SG analysis

Potential 2-D Effects

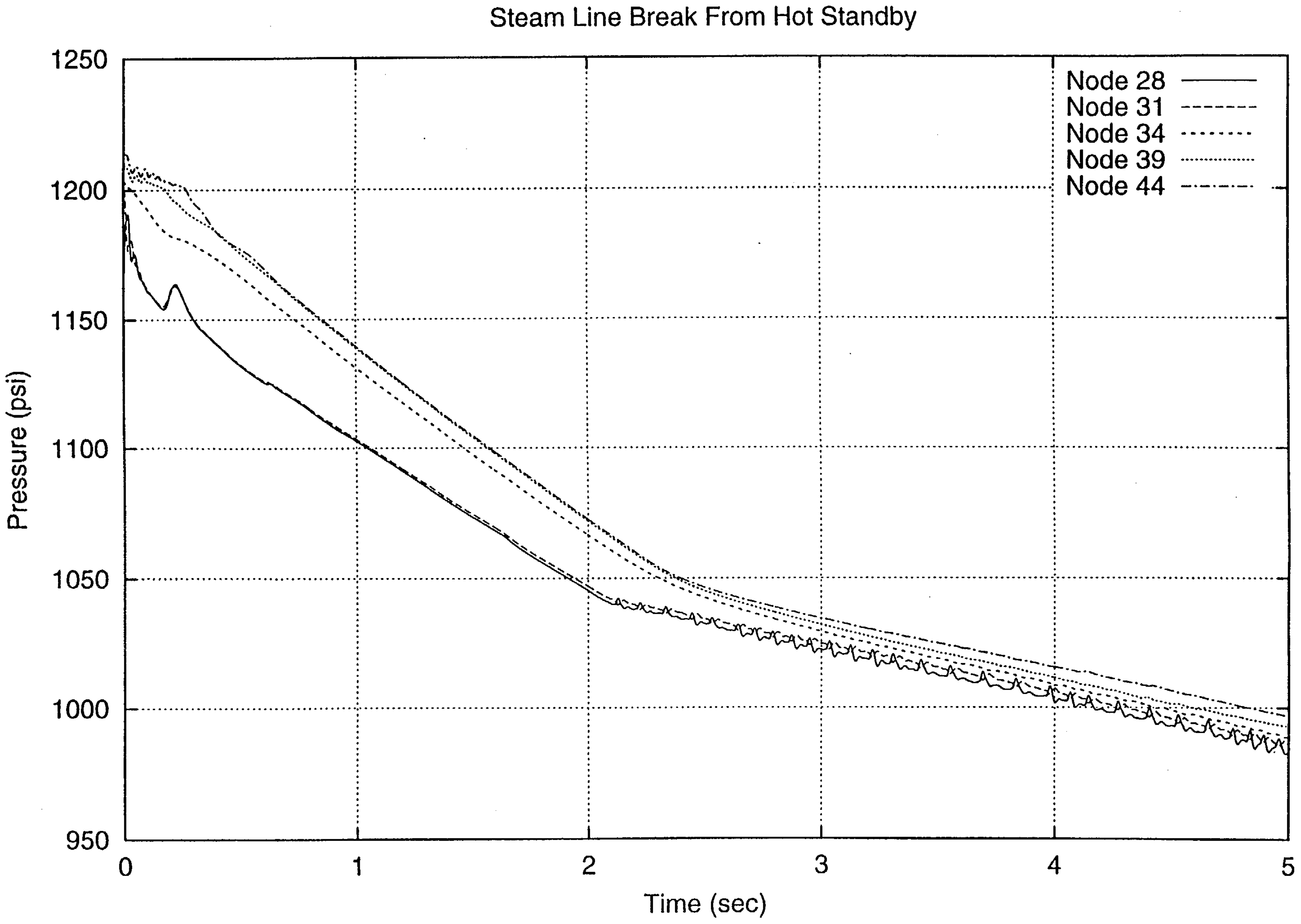
- Independent 3-D ATHOS analyses of a 51 Series SG indicated that cross-effects are small in the Tube Bundle Region for Steady Flow Conditions

Consequence of 2-D Effects on Tube Support Plate Loads

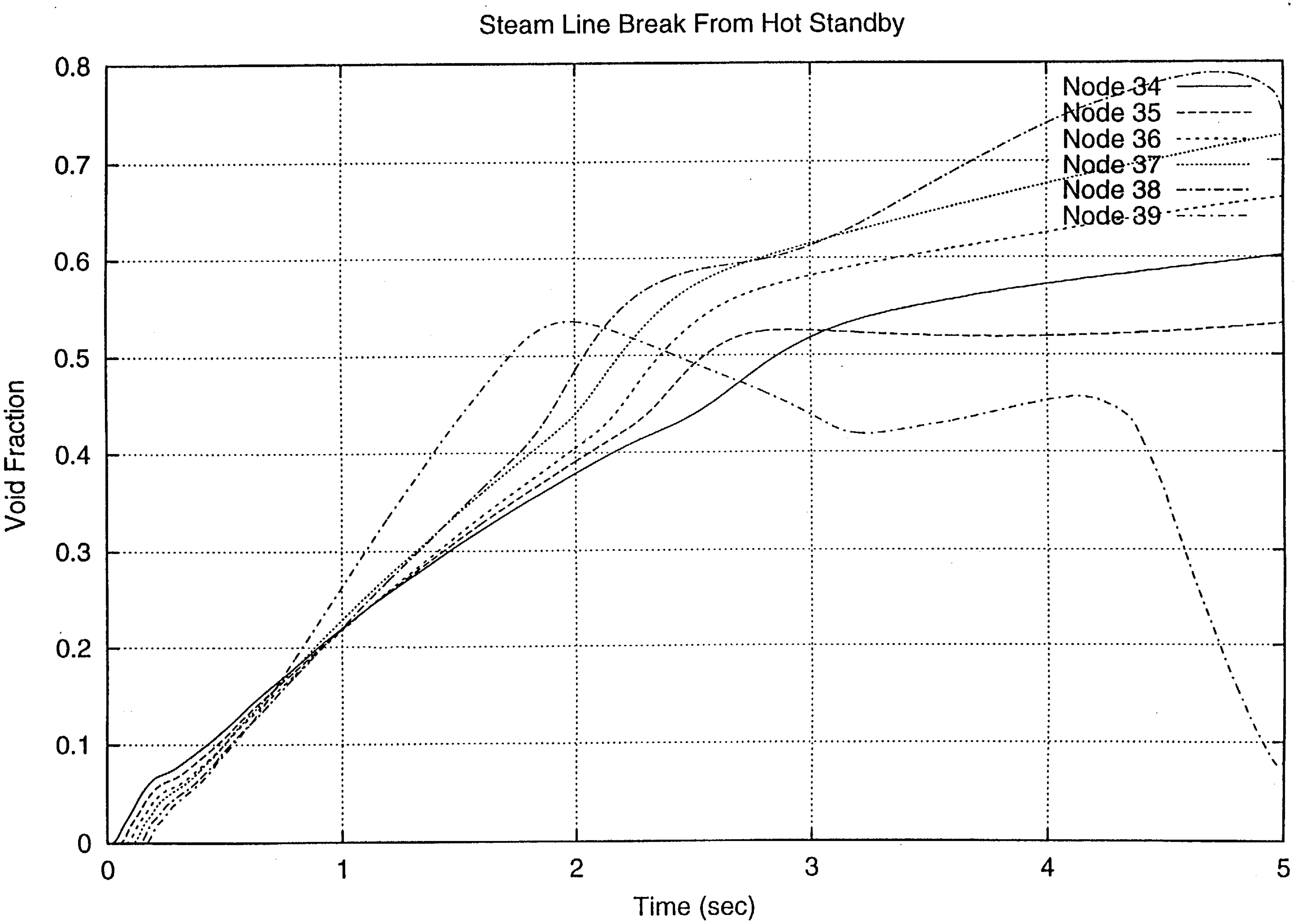
- Variations in flows and pressure differentials within the tube bundle will result in local variations of the load on the support plate
- The support plate will respond as a structural unit to its loads: it will act as an integrator of any local variations of loads

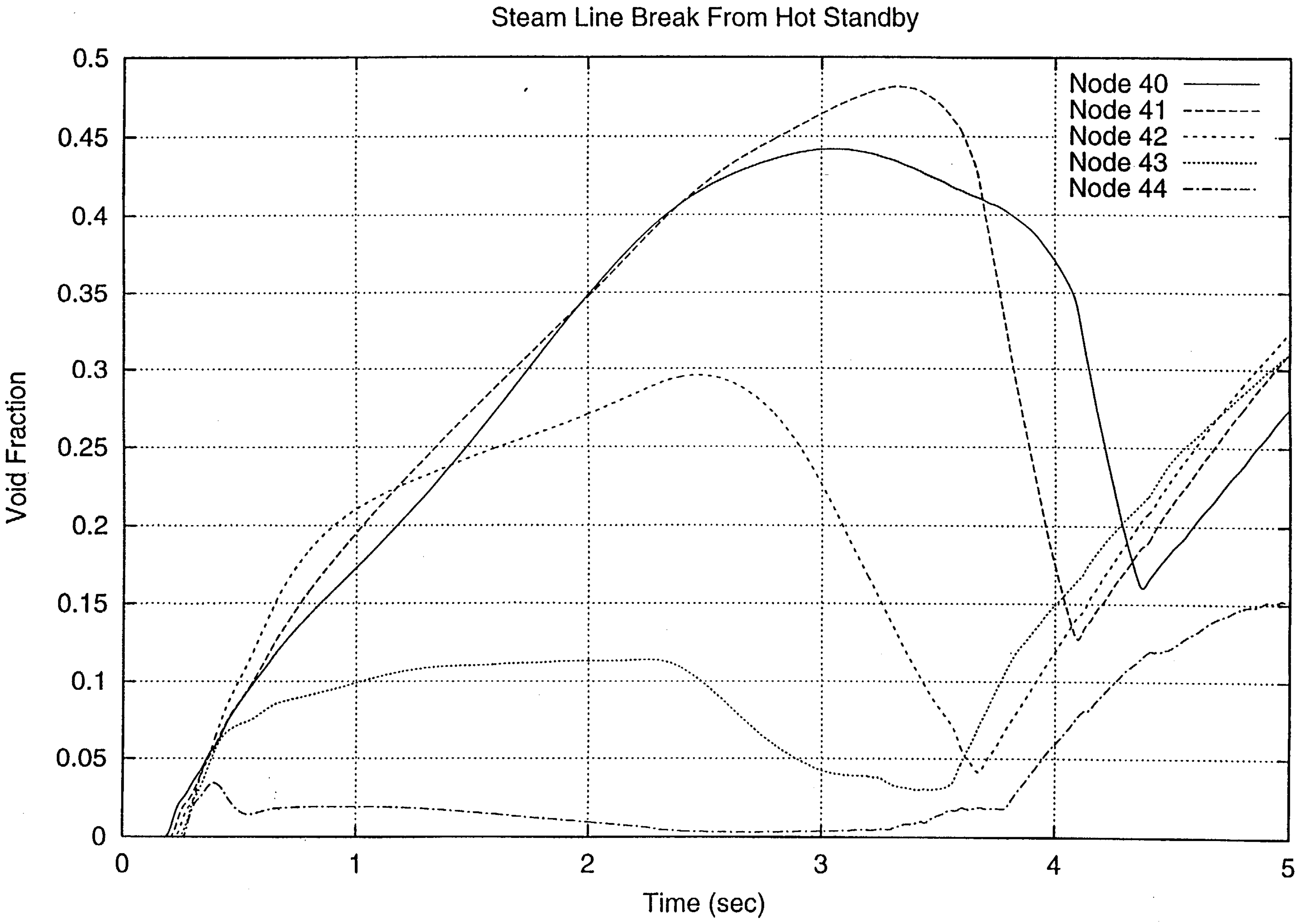
Main Steam Line Break

- Due to Ratios of Flow Areas, Internal Pressure Drops in Tube Bundle Region are not Large
- Dominant TSP Loads are Produced when MSLB occurs from Hot Standby Condition due to “Swell” from Void generation



Steam Line Break From Hot Standby


Steam Line Break From Hot Standby
Void Fraction
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
Time (sec)
Node 34
Node 35
Node 36
Node 37
Node 38
Node 39


Steam Line Break From Hot Standby
Void Fraction
Time (sec)
Node 40
Node 41
Node 42
Node 43
Node 44
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0
1
2
3
4
5

Margin

- Largest indications occur at lowest TSP where displacements are the smallest (0.05")
- The bounding hydraulic load based on a simplified model is a factor of xxx times the predicted RELAP loads
  - Calculated "swell"
  - Upflow through downcomer is zero
- Demonstrates that RELAP appropriately models SLB transient
- **Substantial margin is provided to cover any realistic uncertainties**

Question 1 (STP-2; RAI 10/31/2000; Docket No. 50-499)

Please provide a summary of the lowest resonance frequency, vibration loading, and response for each SG component. This should include SG tubes between the TSPs, the shell, tube sheet, wrapper, and any other components that could affect relative movement between the tubes and the TSPs. For components where vibration is not addressed, please justify its exclusion. Include a discussion of the vibration aspects addressed in designing an SG and, if these were not addressed in your analysis, show why they are not needed in light of the increased flow rate through the flow exit venturi during an MSLB. Also address potential loadings, including sonic waves, that may occur downstream of the SG flow exit venturi and establish if they propagate upstream of the flow venturi, and address transient/vibration behavior, including sonic waves, in the flow exit venturi and establish whether loads are propagated upstream of the venturi via the fluid or via mechanical interactions. Where component vibration is included, then (1) address the capability of the computer codes referenced in your submittal to accurately predict tube/TSP vibration behavior based on interaction of all relevant components, and (2) address how interactions between mechanical components (TSPs, tubes, tie-rods, TSP spacers, phase separators, shell, wrapper, tube sheet, SG exit venturi, other structure and flow control components) and between components and the fluid volumes are modeled to obtain realistic feedback between the vibrating components and between the components and the fluid to correctly predict the transient loading and TSP/tube relative movement. Include the potential for impact loads between loosely fitting components such as TSPs, tubes, and spacers; and include the effect of such items as sludge accumulation and component wear on hydraulic loading and component vibration.

Question 1 (continued)

What is the potential error due to your treatment of "average density" as described in page 6-4?

During vibration conditions with axial cracking, is it possible that the TSP moves a little, thus allowing SG tube expansion, followed by more movement on the next cycle, and so on, with the TSP return movement constrained by the tube expansion?

Fundamental Issue

- What is the relative displacement of the TSP and the tubes during a postulated MSLB?
  - Cracks form at operating conditions
  - Packed crevices are necessary for cracks to form

Lateral Vibrations

- Not a significant mechanism to propagate axial cracks
  - TSPs limit tube deformation
  - Insignificant number of loading cycles during MSLB
    - Laboratory cracks grown by fatigue (cyclic pressure, hoop stress) require many thousands of cycles to propagate the crack
  - Impact loads are insignificant
    - Bench test of tubing showed a load of 500 lbs. required for a ¾" wide bar to cause yield in a tube
  - Packed crevices restrict impact loads at TSP intersections
    - Packed crevices are necessary for corrosion cracking

Lateral Impact Loads

- Lateral impacts tend to inhibit relative axial motion between tubes and TSPs
  - Impact loads lead to friction between tubes and TSPs
  - Friction loads (static and dynamic) are conservatively neglected in the analysis
- Effect on leak rates
  - Calculated leak rates assume open crevices
    - Freespan leak rate used for indications other than IRB
    - Bounding leak rate for IRB are based on large crevice tests
  - Assumed freespan cracks obviate effect of impact loads
  - IRB leak rates are based on clean cracks following pressurization of the tube to force the crack opening into, or nearly into, contact with the TSP

Axial Resonant Vibrations

- Tubes
  - No significant mechanism to cause vibration
  - Stiff - high frequency, low displacement
  - Significant Coulomb damping
- Tubesheet/stayrods
  - Response to dynamic loads already included in the structural model
- TSPs
  - No significant load after initial SLB blowdown
  - Sonic waves are attenuated by upper internals components (dryers, primary separators, mid deck, lower deck)
    - Demonstrated by MULTIFLEX Code analysis in WCAP-14273 (Braidwood-1, 1995)
- Negligible effect for relative axial displacement between tubes and TSPs

Model E SG

- See Figure 3.1, WCAP-15163, Rev. 1
- See Figure 5.1, WCAP-15163, Rev. 1

Model E SG Preheater Region

- See Figure 3.2, WCAP-15163, Rev. 1

Effect of Sludge Accumulation

- Open crevices assumed for TSP load area
  - TSP metal area only considered
  - More than offset by neglecting packed crevice and contact friction loads
- Very little sludge in S. Texas 2 SGs
- Sludge loading on TSPs expected to attenuate dynamic load response

Effect of Component Wear

- No wear has been observed at the TSPs over long term operation
- Short term loading not expected to result in wear
- Postulated wear during a SLB would inhibit relative motion between the TSPs and tubes
  - Friction effects are conservatively neglected in the analysis

Downstream Sonic Waves

- Considered in Byron/Braidwood analysis
  - WCAP-14237
  - MULTIFLEX Code analysis
- Conclusion: Acoustic wave due to SLB is insignificant to TSP loading
  - 1 msec break (guillotine break downstream of outlet nozzle) opening time results in ramp instead of step change
  - Flow restrictor reflects about 90% of the wave
  - Pipe wall friction attenuates wave
  - Area changes in SG between nozzle and bundle diffuse the wave (secondary separator, mid-deck, primary separators, lower deck, U-bend, TSPs)
  - "Because of the complex network of area changes and superposition of the resulting large number of individual acoustic waves, the individual linear ramps combine to results in continuous, smooth changes in fluid parameters rather than discrete step changes" (WCAP-14237; Section 6.7)

Use of "Average Density"

- Uncertainty due to use of average density is 3% or less of combined fluid and metal mass
  - TSP density is a combination of metal and fluid mass
    - Fluid is 25% of total mass
  - Max. difference in total mass is 3% at start and end of critical 2 second window of transient
    - 2 sec. window defined by peak relative tube/TSP displacement
    - Much smaller difference during bulk of 2 second window
- Use of average density is essentially negligible to TSP displacement analysis

Computer Code Validation

- WECAN and *pltdym* have been validated consistent with the Westinghouse Quality Assurance program
  - WECAN is a general purpose finite element code used in this application to calculate component mass and stiffness
  - *pltdym* is a special purpose code developed specifically to calculate TSP motions under SLB loads, including the capability to account for both linear and non-linear interactions between tube bundle components

Displacement Ratchet Mechanism

- Peak TSP loading is early in the MSLB transient
  - If TSP "sticks" at the point of peak load, no increase in displacement can occur because subsequent loading is less
  - If plate does not stick, subsequent displacements are smaller because the loading is smaller
- Presumed vibration will tend to prevent "stick"
- Many intersections are required to "stick" to hold plate in displaced position
  - Large elastic deflection loads from ¾" thick plate
- Occurrence of postulated ratchet mechanism is highly improbable
- Analyses assume TSP sticks at point of max. displacement and stays through max prim.-sec.ΔP many minutes later

---

Question 3 (STP-2; RAI 10/31/2000; Docket No. 50-499)

We do not understand from your Section 7.5 discussion how transient temperature behavior of the SG components was considered when calculating SG component movement For example, the SG shell and tube sheet are thick in comparison to tube thickness and the tubes will cool more rapidly in response to SG depressurization. Since the tubes are constrained at the tube sheet and the TSPs are attached to the wrapper, a differential thermal expansion is expected between the TSP and tubes that we did not see addressed during the blowdown. Further, the tube sheet may not be cooled uniformly, which could induce a bowing that would influence relative movement between the tubes and TSPs. Stayrod/tierod response to changing temperature would also be expected to influence response. A further consideration may be needed due to most tubes remaining active whereas some tubes are plugged and will not respond in the same way.

Transient Differential Thermal Expansion

- Peak pressure loads / plate displacement occur during initial 0.6 seconds of transient
- Thermal response is negligible during first one second of transient
- Best estimate of long term effect is < 0.15" tube/TSP relative displacement
  - Smaller for lower plates

Question 4 (STP-2; RAI 10/31/2000; Docket No. 50-499)

Please amplify your Section 7.2 discussion of stayrod/tierod response to include potential bowing. This should include consideration of bowing due to (1) differential thermal expansion, as identified above, (2) fluid cross-flow, (3) TSPs moving toward each other due to differential pressure, (4) cyclic fluid flow effects, and (5) any propagation of forces from the vicinity of the exit venturi.

Why does local yielding in the preheater region not have a significant effect on response of the hot leg plates (Section 7.3)?

There are a number of locations where fluid makes a 180-degree turn, such as at the edges of TSPs B - H. What is the horizontal "wall" and SG tube deflection behavior at these locations? What are the local TSP deflections due to the vertical component of flow in these turning locations? Include the effect of local void/water slugs in your response.

You have taken the reference case as a steam line break from a hot standby condition and you assumed an initial water level of 503 inches to bound the expected water level based on measurement uncertainties. (Lower water level is stated to provide greater TSP plate loading and movement.) Would it be reasonable to postulate a loss of feedwater event followed by main steam isolation valve (MSIV) closure which in turn causes the MSLB? Would such a case result in a lower initial water level that in turn would cause TSP loads greater than the ones you addressed? Conversely, there is an obvious concern with overfilling events that lead to MSLBs with water in the steam lines. Would such "water solid" situations cause significant TSP/tube relative movement, perhaps via transmission of vibration and/or spike loadings?

Question 4 (continued)

The second paragraph on page 6-1 uses "elastic," "significant yielding," and "in tact" as results of the applicability of the "elastic analysis" approach. Please expand your discussion with emphasis on the potential difference between these terms. How is "significant yielding" consistent with an elastic analysis? What is the loading on the tack welds of the stayrods to TSP A and how does this compare to yield?

The top of page 6-3 states "The median rim width is 1.62 inches, and is the value used for this analysis." How is this consistent with a variable rim width that may deform differently at various locations?

What is the influence of primary side depressurization on SG tube response during the MSLB? (The question is meant to address the change in tube "stiffness" with change in primary-side pressure.)

In Section 8.3, the bounding tube leak rate is based upon the pressure operated relief valve (PORV) setting plus uncertainty. Should there be an allowance for pressure drop through the valve and opening time? Are there conditions where PORV opening may not occur and the

Tierod / Spacer Bowing

- Little effect on tube/TSP displacements
- Tierods are in tension / bowing has no effect
- Spacer compression for lower plates ranges from 0.1 to 3 mils
- Spacer bow would not affect analysis conclusions

"Local Yielding" in the Preheater

- 3 volt ARC apply only to the HL TSPs
- Local yielding of cold leg plates in the preheater will not have a significant effect on hot leg displacements

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"Elastic", "Significant Yielding", "Intact"

- Terms applied to validate the elastic structural model
  - "Elastic" refers to tierod/spacer stresses compared to material yield
  - "Significant yielding" differentiates from "local yielding" of TSPs on cold leg which does not influence hot leg displacements
  - "Intact" applies to integrity of welds joining the vertical bars and wedges to the partition plate and wrapper. Weld integrity conservatively based on ASME Code stress limits.

TSP Average Rim Width

- TSP rim width continuously varies
  - several tube rows width variation
  - No large TSP circumferential spans with narrow rim width
  - Max TSP displacement occurs in the interior region of the plate, not on the periphery
    - Stayrods provide additional supports
- Rim width variation is not significant for locations of maximum displacement

Plate A to Preheater Tierod Tack Welds

- Tack welds are essentially unloaded
  - Plate B (bottom preheater plate) loaded downward with significant pressure load
  - Preheater tierods are in compression – welds are not loaded
- No influence on HL plates displacement relative to the tubes

Loss Coefficient Correlation

- *From Question 2: Please justify the applicability of the referenced test facility to determination of TSP loss coefficients. Also address the adequacy of your Figure 4-4 comparison of a correlation with data when the loss coefficient of interest appears to be outside the range of the data.*
- Figure 4-4, "Correlation Coefficient" is the constant in the equation and not the value of the loss coefficient shown on the figure.
  - The best value of the correlation coefficient, 1.1, is shown in the correlation equation.
- Figure 4-4 loss coefficients are based on approach flow area
  - Modify by square of ratio of flow area to approach area to obtain loss coefficients summarized in Table 4-2
- Validity of loss coefficients verified by comparing calculated circulation ratio to test data for circulation ratio

Loss Coefficient Data

- See Figure 4.4; WCAP-15163, Rev. 1

Test –Based vs. Calculated Loss Coefficients

- See Table 4-2; WCAP-15163, Rev.1

Question 5 (STP-2; RAI 10/31/2000; Docket No. 50-499)

The staff has reviewed the basis for the estimated probability of induced tube rupture and finds that further justification is necessary. The analysis appears to assume that the dominant contribution to the probability of rupture is the uncertainty of the burst pressure correlation for a crack that is assumed to be a precisely known length. However, it is the uncertainty of the actual length of the crack that is exposed in the free span that will dominate the burst probability. That will be dominated by the uncertainty in the length of crack potentially exposed by the motion of the TSPs under the design-basis accident conditions. In addition, although not a dominant issue, the potential for a crack to initially extend a short distance outside the confinement of the TSP appears to be more significant to the probability calculation than is the burst pressure correlation uncertainty that was considered in the application. The conditional tube rupture probability analysis should address these factors.

South Texas 3V ODSCC ARC

NRC RAI on Probabilistic Analysis

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NRC RAI — Probability of Burst

- Question regarding the dominant contributor to the uncertainty associated with the probability of induced tube burst.
  - Was the burst pressure correlation uncertainty treated as the dominant factor?
  - Could the potential for the crack to initially extend outside of the TSP be a significant contributor to the burst probability?
  - "The conditional tube burst probability analysis should address these factors."

Review of the Burst Analysis

- The uncertainty in the burst correlation was not treated as the dominant factor in determining the the probability of burst.
- The probability of burst of a throughwall crack is influenced by the following:
  - The exposed throughwall length of the crack.
  - The tube-to-TSP clearance.
  - The burst pressure correlation statistical error.
  - The strength of the tube material.

Exposed Throughwall Length

- The limiting transient for maximum TSP displacement is the MSLB initiating from hot-standby conditions.
  - The maximum displacement is 0.13" (Plate M) for 3 volt ARC TSPs
  - The maximum exposed length that results in a probability of burst of 10^{-5} if there are 43,659 TW cracks is 0.31".
- The conservative assignment in excess of the maximum value obviates the need to consider the uncertainty.

Exposed Throughwall Length (cont.)

- Treatment of the uncertainty would be desired if it is necessary to reduce the calculated probability by removing conservatism.
- The sensitivity of the calculated probability is dominated by factors for which the distribution of uncertainty is not bounded.
  - Length — Bounded
  - Clearance — Bounded
  - Burst Correlation — Distribution
  - Material Strength — Distribution

Tube-to-TSP Clearance Bound

- Examination of fabrication practice leads to a reasonable estimate of the distribution of the clearances.
- Upper bound of the fabrication clearance, 23 mils, used to estimate the effect on the burst pressure.
  - The need to separately treat the uncertainty is obviated by the use of the upper bound value.
- Most clearances will be less than the upper bound value.
- The clearance must be reduced by corrosion products or the stress corrosion cracking would not occur.

Burst Pressure & Material Strength

- The statistical errors from the correlation of the dimensionless burst pressure are normally distributed.
- The statistical variations of the material strength are normally distributed.
- The distribution of the product of the dimensionless burst pressure and the material strength is skewed right.
  - Demonstrated by Monte Carlo simulation.
  - Deterministic treatment as a normal distribution is conservative for lower bound burst pressures.

Exposure of Existing Cracks

- No evidence of growth of cracks from inside to outside of the tube-to-TSP intersection.
  - Outside indications with multiple initiation sites
  - Indicative of influence of sludge deposits
- Indications outside the intersection are shallow.
  - Too small to be detected by NDE.
  - Deepest from 0 to 50% over the length of 0.11".
  - Longest, about ¼" with depth of 11%.
- The potential for cracks to extend outside of the TSP is not a significant contributor to the burst probability.

Conclusions

- The evaluation of the burst pressure probability is based on a conservative treatment of the parameters contributing to the uncertainty of the result.
- The result of the evaluation appropriate to the situation and the probability of burst of each individual indication is negligible.
- The overall probability of burst calculated does not have to be modified and criteria requirements relating to the probability of burst are met.