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and 50-391

MEMORANDUM FOR: Document Control Desk Personnel

FROM: Peter S. Tam, Senior Project Manager
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Division of Reactor Projects - I/II

SUBJECT: WATTS BAR NUCLEAR PLANT -- TRANSMITTING DOCUMENT TO CENTRAL FILES AND MAKING IT PDR-AVAILABLE (TAC M79718 and M80345)

Please file the enclosed document, which is the handout prepared by TVA for the site review of September 24-25, 1991, on the issue of feedwater check valve slam (Watts Bar SER Supplement No. 6, Outstanding Issues 20(a)).

By copy of this memorandum, NRC and local PDR personnel are provided with a copy of the same document for PDR display.

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cc. NRC and local PDR
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Evaluation of Feedwater Line For Concurrent Feedwater Check Valve Slam and Seismic Loads

Discussion of Analysis Methodology

9-24-91

Outline

- Introduction
- Analysis Model
- Loading Conditions
- Acceptance Criteria
- Summary
- Conclusions

Introduction

Purpose: To demonstrate pressure boundary integrity of the feedwater system following a simultaneous main feedwater header break, check valve slam, and seismic event. The check valve slam event was identified in Westinghouse Bulletin 79-9.

Method: Nonlinear time history analysis using ANSYS.

Scenario: Initial conditions include deadweight, pressure, and thermal expansion (including anchor motion at steam generator) at normal operating temperature.

SSE initiates break at onset of strong motion.

Check valve slam transient occurs concurrent with seismic strong motion.

Seismic load continues after check valve slam transient ends.

Status: Model and load generation for loop 4 feedwater line completed.

Time history analysis of loop 4 feedwater line in progress.

Background

Identification of Transient:	Westinghouse Bulletin 79-9. Initial transient loads developed in early 80's using RELAP4.
TVA Analysis:	RELAP5 used to generate transient loads. Linear analysis for check valve slam loads performed in 1982. Adequacy of cut-off frequency in mode superposition method questioned in 1986.
Bechtel Analysis:	SWEC regenerated transient loads in 1989 using RELAP5. Bechtel performed exploratory linear analyses to determine feasibility of support modifications to qualify feedwater line. Bechtel performed non-linear analysis in 1990 using check valve slam loads.

Analysis Model - Piping Geometry

Loop Selection: Loop 4 feedwater line selected for analysis has highest strain from initial checkvalve slam analysis.

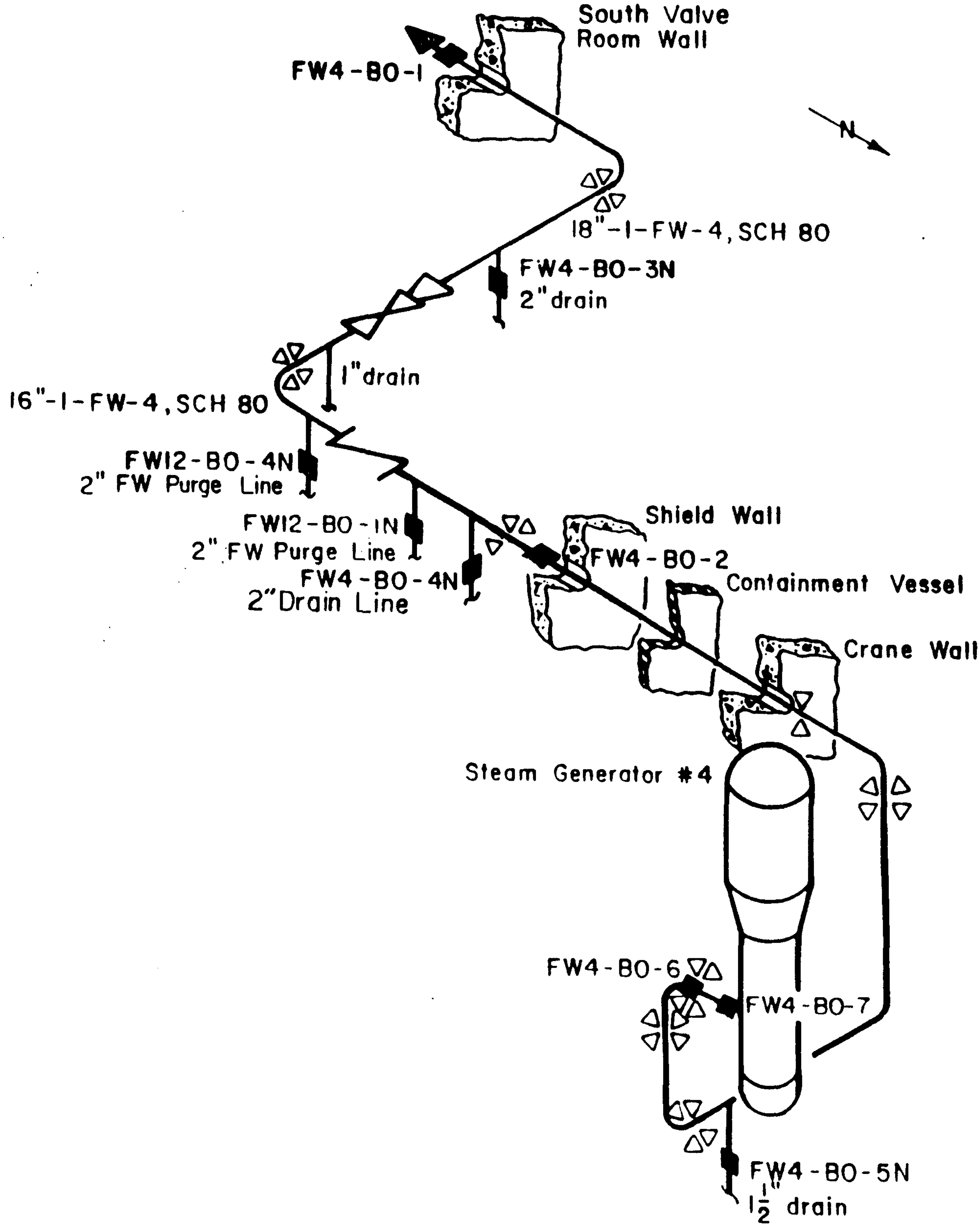
Geometry: 16"/18" feedwater line from steam generator to flued head anchor in the auxiliary building.

2" bypass line around the feedwater check valve.

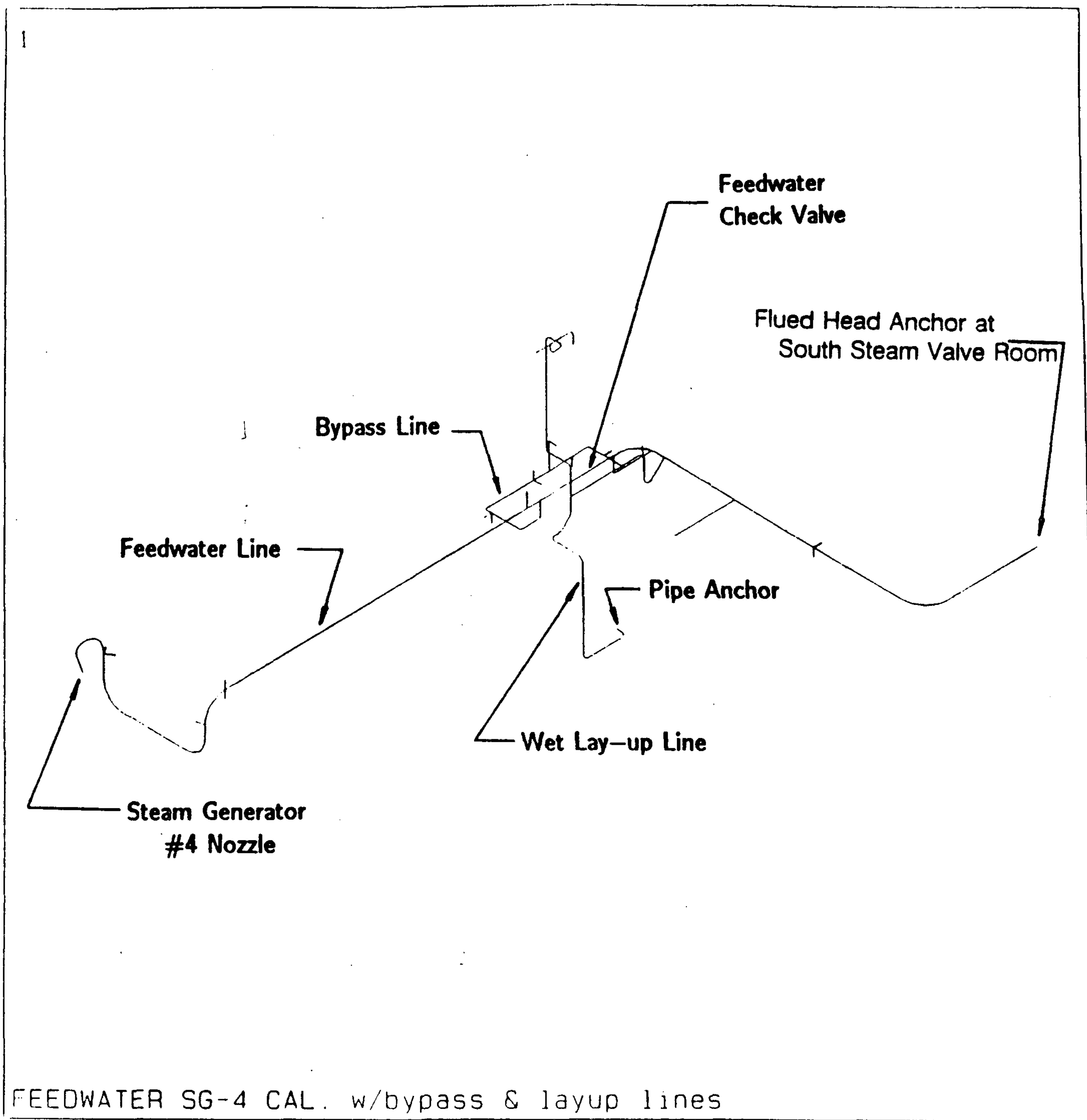
4" wet lay-up line up to isolation valve and adequate overlap region.

1" drain line.

All other lines will be evaluated as necessary to ensure pressure boundary integrity.



Loop 4 Feedwater Line
Figure 1



Analysis Model
Figure 2

Analysis Model - Piping Elements

Material Properties: Bilinear stress-strain curves, based on ASME Code values of E, S_y, and S_u and published values of ϵ_u.

Analysis Model - Supports

Supports: Ductile supports (capable of yielding and undergoing predictable deformation) modeled using elastic-perfectly plastic load deflection curves. See Figure 3a.

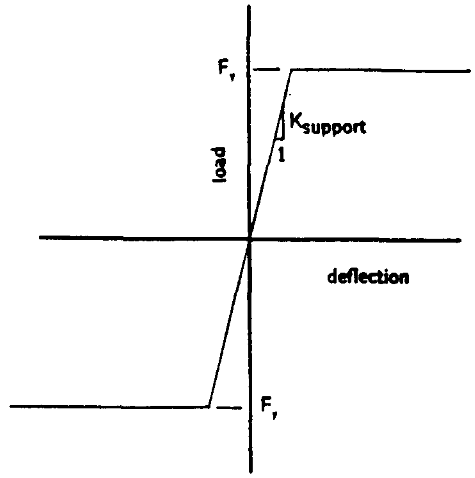
Non-ductile supports modeled using "break-away" curves. See Figure 3b.

Single-directional supports also appropriately considered (eg., downward only supports). See Figure 3c.

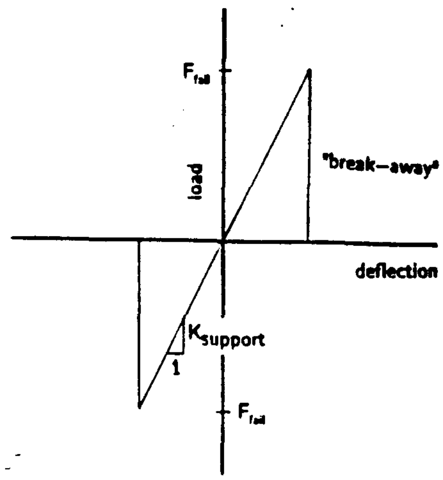
Support load properties/behavior developed.

Rupture Restraints: Gap elements used to account for clearance between pipe and shims.

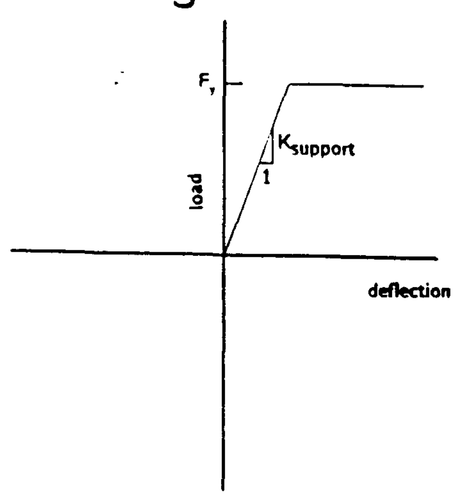
ANSYS tracks gap open-close status during analysis and includes closure effects in solution.



Ductile Support Load–Deflection Curve
Figure 3a



Non–Ductile Support Load–Deflection Curve
Figure 3b



One–Way Ductile Support Load–Deflection Curve
Figure 3c

Loading Conditions - Initial

- **Maximum feedwater check valve slam loads are used with normal operating conditions:**

  Temperature

  Pressure

  Deadweight of pipe, components, and contents.

  Thermal anchor movements at steam generator.

Loading Conditions - Seismic

- Three orthogonal (NS, EW, and Vertical) input time histories generated to envelop spectra for three structures.
- Envelope of OBE and SSE for Sets B + C.
- Reg. Guide 1.61 damping (2%/3%).
- Event duration - 19 sec.
  Strong motion duration - approx. 6 sec.
  Time step - .005 sec., except .001 sec. during
  check valve slam event.
- SRP requirements met for time history development.

Loading Conditions - Check Valve Slam

- Force time history developed based on guillotine rupture of 32" feedwater header. Break development time of .001 sec. used per SRP 6.2 guidance.

- Event duration - 0.5 sec.
  Time step - .001 sec.

- CVS transient begins at 4.5 sec. into seismic event at initiation of strong motion.

Acceptance Criteria

Piping: Calculated stresses compared to maximum allowable values as specified in ASME Appendix F.

Supports: Load-deflection output time history reviewed against behavior model to ensure compatibility.

Rupture Restraints: Gap closure output time history reviewed, maximum loads reviewed against capacities to determine accuracy of modeling.

Results to Date

- First pass exploratory analysis performed with combined check valve slam and seismic load.
- Results show exceedance of calculated capacities for nine supports. Three supports remain functional after the check valve slam event.
- Highest stresses in exploratory run occur at first elbow near the steam generator.

Final Analysis Refinements

- Refine model to obtain proper distribution of elastic and plastic elements for appropriate response.
- Refine support and rupture restraint models as required for analysis compatibility.
- Reexamine conservatism of seismic time histories.

Summary

- The purpose is to demonstrate pressure boundary integrity of the feedwater system following a simultaneous header break and seismic event.

- Nonlinear analysis is performed for loop 4 feedwater line. Pipe, support, and rupture restraint nonlinearities are considered.

- Operating, seismic, and feedwater check valve slam transient loads are applied concurrently.

- The acceptability of stresses are checked against ASME Section III Appendix F allowables.

- The other 3 feedwater lines will be qualified by comparison with the loop 4 feedwater analysis after the final results are obtained.

Conclusions

- Analysis methods and loads consistent with SRP requirements.
- Acceptance criteria consistent with ASME Code requirements.
- Pressure boundary integrity will be demonstrated for applicable Level D load combination.