TVA

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JAN 11 1993

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

WATTS BAR NUCLEAR PLANT (WBN) - UNITS 1 AND 2 - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) - OUTSTANDING ISSUE 20(a) - FEEDWATER CHECK VALVE SLAM - TAC M79718 AND M80345

REFERENCE: NRC letter to TVA, November 20, 1992, Request for Additional Information on Outstanding Issue 20(a)

The purpose of this letter is to provide NRC the additional information requested in the above referenced correspondence, relative to the Watts Bar Feedwater Check Valve Slam evaluation.

The TVA responses to these RAIs are provided in the enclosure to this letter.

No new commitments are contained in this submittal.

Should there be any questions regarding this information, please telephone P. L. Pace at (615) 365-1824.

Very truly yours,

W. J. Museler

William J. Museler

Enclosure
cc: See page 2

JAN 11 1993

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ENCLOSURE

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI)
OUTSTANDING ISSUE (20a)
FEEDWATER CHECK VALVE SLAM (TAC M79718 AND M80345)

Question 1 - The response states that "Material properties used in the nonlinear analysis have been revised to be consistent with the results of ASME Code-sponsored tests." In order for the staff to evaluate the adequacy of the properties used in the non-linear analysis, please identify the ASME Code-sponsored tests and describe which material properties were revised to be consistent with the test results.

Response - The "ASME Code-Sponsored tests" referred to are key materials development testing of SA-333, Grade 6 ferritic steel that was performed to support Section XI of the Code. The information obtained from the tests are the properties needed to characterize the stress-strain relationship for the piping material (SA-333, Grade 6).

The source data used to define the stress-strain data used in the evaluation of the WBN Feedwater line were taken from References 1.1 and 1.2.

These two sources provide data for ten stress-strain curves of SA-333, Grade 6 material that formed the bases for a lower bound curve that was used to construct the tri-linear representation used for the WBN Feedwater analysis (See Attachment 1). As shown in the attachment, key numerical values from the analysis curve are:

$$S_y = 27.1 \text{ ksi}$$
$$S_u = 65.6 \text{ ksi}$$
$$E = 26.0 \times 10^6 \text{ psi}$$

The lower bound curve was compared to CMTR data for the WBN feedwater lines to ensure that the lower bound material curve is representative of the installed material. CMTR data was not used as input to the analyses.

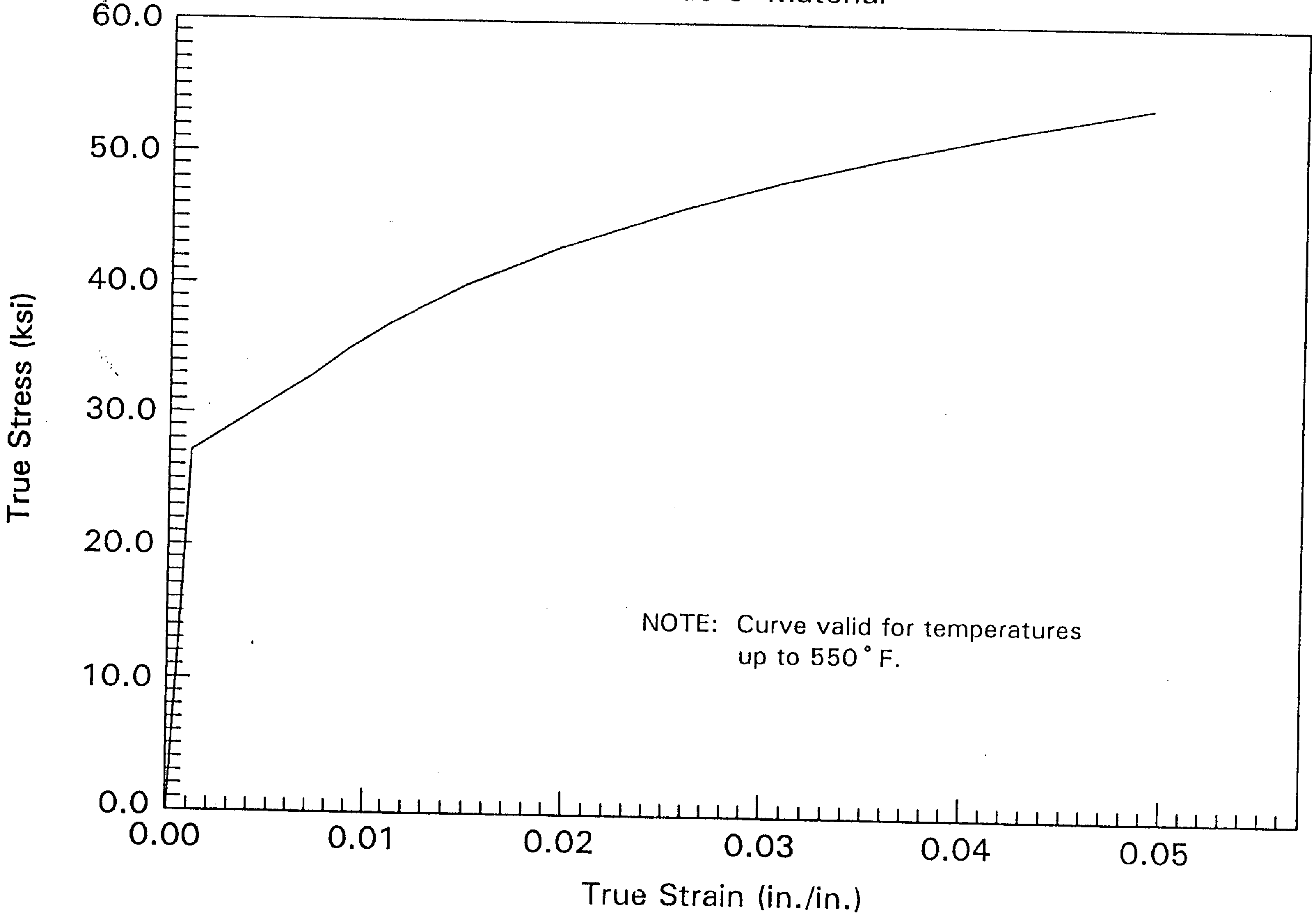
References

1.1 EPRI Report NP-6045, "Evaluation of Flaws in Ferritic Steel Piping," October 1988.

1.2 NUREG/CR-4082, "Degraded Piping Program - Phase II," Volumes 1 through 8, 1989.

FIGURE 1: ASME Lower Bound True Stress-Strain Curve

SA-333 Grade 6 Material



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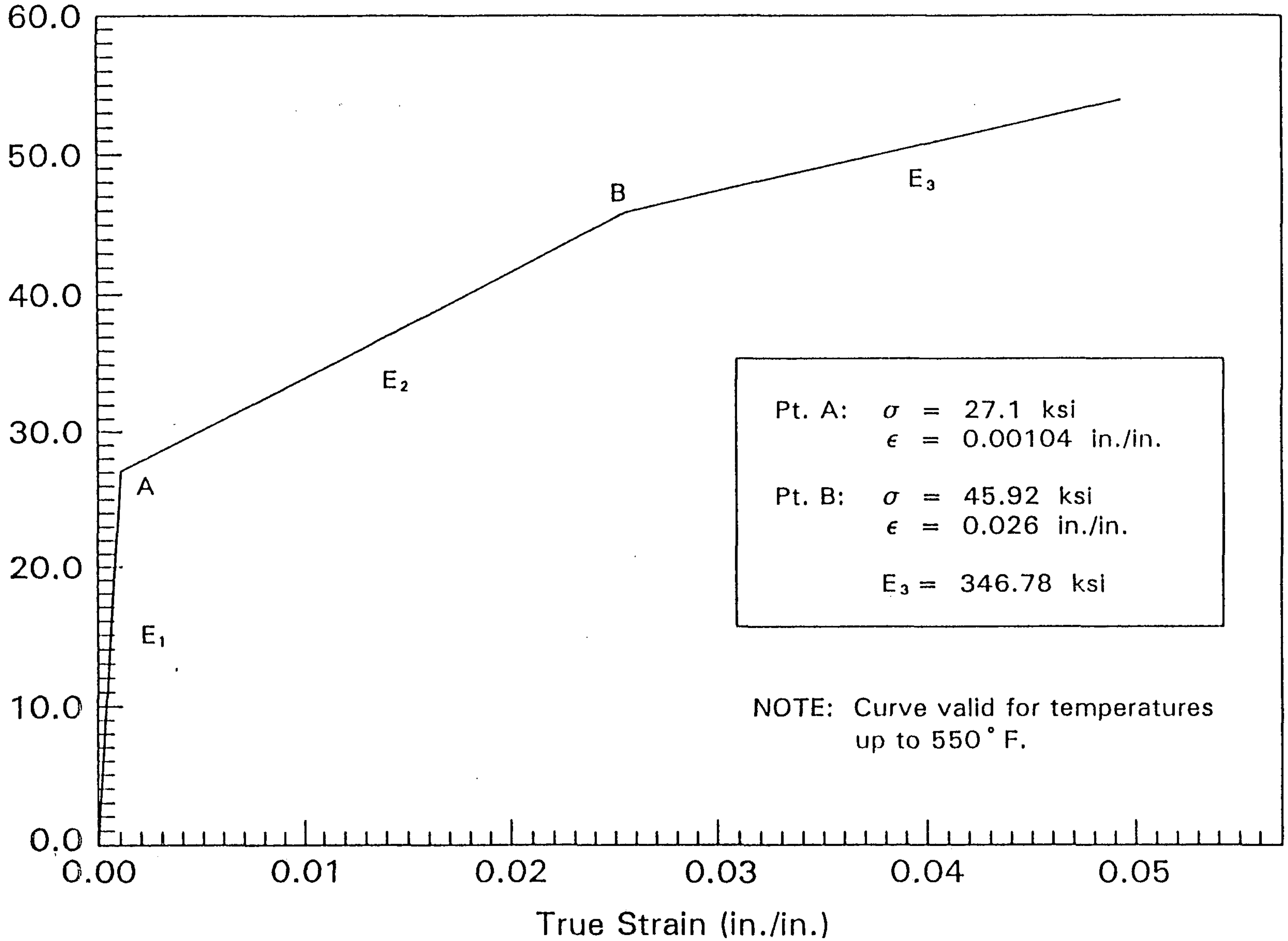
ATTACHMENT 1

FIGURE 2: Recommended Tri-linear True Stress-Strain Curve

SA-333 Grade 6 Material



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ATTACHMENT 1

Question 2 - The response states that "For the final analysis, individual seismic input time histories meeting Standard Review Plan (SRP) requirements have been generated for each structure separately." Please identify the specific SRP requirements utilized and describe how the input time histories were generated to meet those requirements.

Response - Seismic time histories were generated for four separate structures. For each structure, three orthogonal time histories were developed from an initial "seed" time history using an iterative Fourier analysis/synthesis procedure .

- Each time history was synthesized such that the 3% damped spectra envelopes the relevant target spectra according to the frequency intervals and enveloping criteria in II.1.b of [2.1].

- Target spectra were the (Set B+C) in-structure spectra for the structures supporting the four feedwater lines.

- The three acceleration components associated with the three mutually orthogonal axes have been synthesized such that they are "statistically independent" as described in II.6.b(2) of [2.2].

References - 2.1 "Standard Review Plan Section 3.7.1, Seismic Design Parameters", USNRC Office of Nuclear Reactor Regulation, NUREG-0800, Revision 1, July 1981.

2.2 "Standard Review Plan Section 3.7.2, Seismic System Analysis", USNRC Office of Nuclear Reactor Regulation, NUREG-0800, Revision 1, July 1981.

Question 3 - The response states that "The main feedwater lines for Loops 1, 2, and 4 were uniquely analyzed. The main feedwater line for Loop 3 is qualified by similarity to Loops 2 and 4".....

Although the configuration and forces may be similar, examination of the piping isometrics indicates that the number and location of the rigid restraints (RR), snubbers (DS) and pipe whip restraints (PD) of the loops are not similar. In order for the staff to accept the validity of the similarity assumption, please provide the logic, basis and details to substantiate the assumption in view of the differences noted above.

Response Similarity of the feedwater line pipe supports and whip restraints is summarized in the following paragraphs. Please refer to Attachment 3-1 for piping and support arrangement.

Pipe Whip Restraints

For the inside containment piping, review of whip restraint drawing 48W1700-2 shows that the whip restraints on Loops 3 and 4 are essentially identical. Both lines have four PD's located as follows:

1. ±Y on the (X, n/s) run immediately inside the crane wall.

2. three lateral directions (±Z, and in the X direction towards the steam generator) on the riser immediately inside the shield wall.

3. three lateral directions (±Z, and in the X direction away from the steam generator) on the riser adjacent to the steam generator

4. vertical (±Y) and one direction of lateral (Z) at the steam generator nozzle.

For the outside containment piping, review of whip restraint drawing 48W1708-01 shows that both Loops 2 and 3 have four directional restraints on both the X and Z runs close to the 90° elbow. The distances from the elbows to the whip restraints is essentially equal in the two loops.

In addition, since all supports outside containment for Loop 3 remain functional, no whip restraints are actively engaged to provide support for the check valve slam event.

Question 3 - Feedwater line similarity....(continued)

<u>Pipe Supports</u> (Attachment 3-1)

During the CVS+SSE loading, all supports are "active". Therefore, rigid restraints and snubbers are considered together.

Based on the analyses of Loops 1, 2, and 4, the critical portion of piping is between the crane wall and the steam generator.

The Loop 3 outside containment piping is well supported with five Y supports and lateral supports in both horizontal directions. This is similar to the support scheme for Loop 2 which has four vertical supports along with two lateral supports.

The Loops 3 and 4 inside containment piping are geometrically similar; if the supports influencing the inside containment piping are also similar, then the Loop 4 results can be applied to Loop 3.

- Both systems have X and Z snubbers inside containment. However, in the Loop 4 analysis, these snubbers are nonfunctional. Thus these supports are not considered to support the Loop 3 piping and are not considered in the similarity evaluation.

- Both systems are supported by two directional ($\pm$X, $\pm$Y) supports at the guard pipe connection to the shield wall (1-03A-284 and 1-03A-333, for Loops 3 and 4, respectively).

- Both systems are supported by $\pm$Y supports at the crane wall side of guard pipe (1-03A-282 and 1-03A-322, for Loops 3 and 4, respectively).

- Both systems have supports in the direction of the long run through the containment penetration. These supports are adjacent to the first outside containment elbows. For Loop 4, support 1-03A-328 is approximately 6'-6" from the centerline of the run pipe. Loop 3 Support 1-03A-289 is approximately 2'-1" from the run pipe centerline. Thus Loop 3 is better supported than the previously qualified Loop 4.

  The loads for Loop 3 support evaluations utilized an envelope of the corresponding support loads from the Loops 1, 2, and 4 analysis, thus providing for the maximum enveloping load for Loop 3 support evaluations.

'Question 3 - In addition, substantiate the similarity claims for the Bypass and Wet Layup lines....

Wet Layup Line (Attachment 3-1)

For the layup lines of all loops, the pressure boundary portion of the piping extends to the second isolation valve. These valves are located very close (within 10' of run pipe) to the feedwater lines. The remainder of the piping requires qualification only to support the piping between the feedwater line and the valves.

The Loop 1 and 4 wet layup lines were explicitly evaluated for the effects of the combined CVS+SSE.

The layup lines are small (4") relative to the feedwater lines (16"). Thus displacements of the feedwater line will be the most significant contributor to loading of the layup lines.

For both analyzed layup lines:

- there is an elbow in the layup line immediately adjacent to the feedwater header followed by a straight run of piping.
- After the straight run, the lines branch off in two directions from a tee near the safety related boundary.

For Loop 1:

- On Loop 1, both branches are anchored close to the tee.
- Calculated stresses were much less than the allowable (29.7 ksi v. 45.9 ksi)

For Loop 4:

- the lower branch is anchored
- the upper branch extends a considerable distance without anchors, including additional branch points. Therefore, two lateral supports were modified to isolate the non-pressure boundary piping (47A496-6-7, X and Z Snubbers).

Question 3 - In addition, substantiate the similarity claims for the Bypass and Wet Layup lines....(continued)

- Of the four loops, only Loop 4 has valves (other than the isolation valves) in the boundary piping. These valves are large (two valves, each approximately 500 pounds).

- Despite loads from the large valves and non-anchored boundary piping, stresses were still less than the allowable (44.4 ksi v. 45.9 ksi).

For Loops 2 and 3:

- Pressure boundary piping extends less than 10' from the feedwater line(s).

- There are no large valves supported by the piping

- The non pressure boundary portion of the piping is well supported.

- There are no supports located in close proximity to the branch point. This provides adequate flexibility for the layup lines to "follow" the movements of the feedwater line(s) without developing significant stresses.

In conclusion, layup lines for Loops 1, 2, 3 are similar with isolation valves close to feedwater line, reasonable flexibility between the first support and the main run pipe, with the remainder of the pipe being well supported. Therefore, demonstrating qualification of Loop 1, in addition to the more heavily loaded and more complex Loop 4, is adequate to demonstrate the pressure boundary integrity of all four loops.

Question 3 - In addition, substantiate the similarity claims for the Bypass and Wet Layup lines....(continued)

Bypass Lines (Attachment 3-1)

The bypass lines are 2" lines around the check valves in the 16" feedwater line(s). There is one bypass line per loop. The complete bypass line is part of the feedwater system pressure boundary.

The Loop 1 and Loop 4 bypass lines were explicitly evaluated for the effects of the CVS+SSE loading. The maximum longitudinal stresses in both Loop 1 (33.9 ksi) and Loop 4 (31.8 ksi) were much lower than the allowable general membrane stress intensity of 45.9 ksi.

The general configuration of the bypass lines of all fours loops is similar. Branches from the feedwater lines drop approximately 1 foot and then form a square pattern. The only significant mass on the lines, a flow control valve, is on the far side of the square remote from the feedwater line.

Each of the four bypass lines includes a short, open ended, 1" NPS branch line with two valves. These branches start out as 2" lines and, within 6", reduce to 1" NPS. For both of the rigorously analyzed loops (1 and 4) this transition from 2" to 1" is the point of maximum stress. Considering these branches as cantilevers, the lengths from the transition point to the end of the second valves are approximately: 29", 19", 22", and 23" for Loops 1 through 4, respectively. Since the cantilevers for Loops 2 and 3 are shorter than those for Loops 1 and 4, and since the seismic loads in the north valve room are smaller than those in the auxiliary building, the stresses for Loops 2 and 3 will be less than the already low values calculated for Loops 1 and 4.

In addition to the 1" branch discussed above, Loops 2 and 3 also have a similar 2" branch with valves. The configuration of both loops is similar; the lengths from the branch point to the end of the second valves are approximately 41" and 38" for Loops 2 and 3, respectively. Although the 2" branches are longer than the 1" branches,

- moment capacity for the 2" is greater than the 1" by the ratio of the section moduli (4.5)

- weight of 2" is greater than 1" (2.54)

Question 3 - In addition, substantiate the similarity claims for the Bypass and Wet Layup lines....(continued)

In conclusion, based on the relative lengths, weights, and capacities of the lines, the analysis of the Loop 1 and 4 bypass lines show that stresses from the combined CVS+SSE are much below the allowable general membrane stress. It is concluded that the pressure boundary integrity of the Loops 2 and 3 piping is demonstrated.

Question 4 - Provide the following information for a typical loop:

Item a - The ANSYS input listing for the analysis run.

Response - The input for the first step of the Loop 1 analysis (from 0.0 to 3.0 seconds) is included as Attachment 4-1. The input includes PREP6 load generation (preprocessing), PREP7 model generation, and POST26 review of results. Note that the echo print of the displacement time history tables was suppressed in this run to reduce output volume.

The input for step 3 of the Loop 4 analysis (3.5 to 4.0 seconds) is included as Attachment 4-2. This input is representative of a "restart". In addition, this input includes the complete definition of the seismic time histories.

Question 4 - Please provide the following information (continued)...

Item b - An isometric drawing of the loop showing the locations of the significant nodes/elements, coordinate systems, and major components. For each support on the drawing, show the post-event status (functional or failed) and identify the supports which were upgraded for the analysis.

Response - A marked-up copy of the "T-Pipe" isometric is included as Attachment 4-3. This isometric shows locations of pipe supports and whip restraints. Selected ANSYS node and element numbers are marked in blue and red, respectively (note that ANSYS node numbers are based on the T-Pipe model).

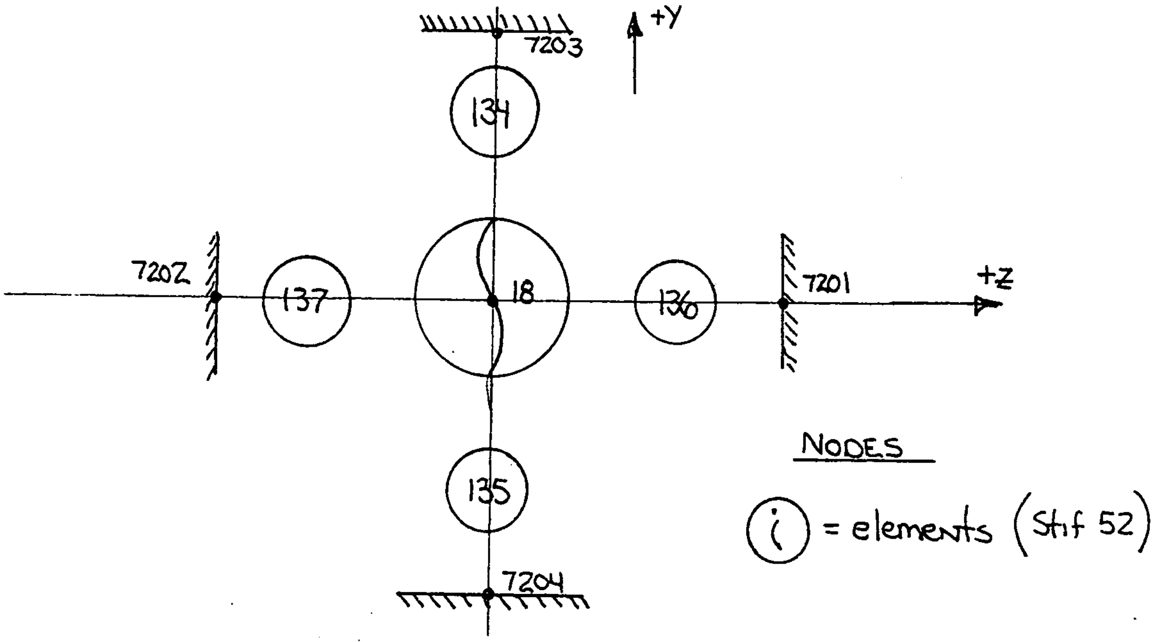
Support status is tabulated below:

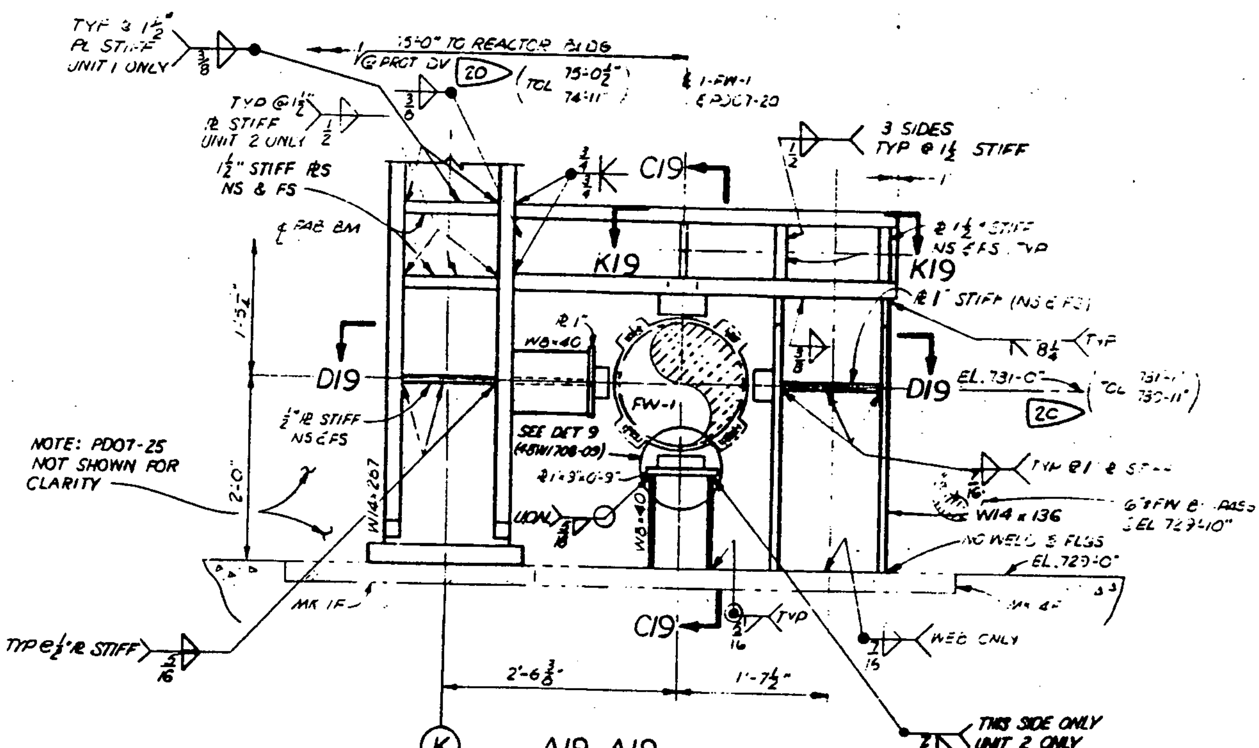
Support	Description	Post-Event Status	Modified
1-03A-200	N/S (Z) Snubber	Non-Functional	No
1-03A-201	E/W (X) Snubber	Non-Functional	No
1-03A-202	N/S (Z) Rigid	Functional	Yes
1-03A-203	E/W (X) Rigid Y Rigid	Functional	Yes
1-03A-204	Y Rigid	Functional	Yes
1-03A-205	E/W (X) Snubber	Functional	Yes
1-03A-206	Y Rigid	Functional	Yes
1-03A-208	-Y (DW Only) Rigid	Functional	Yes
1-03A-209	-Y (DW Only) Rigid	Functional	Yes
1-03A-210	E/W (X) Rigid Y Rigid	Functional	No

Question 4 - Please provide the following information (continued)...

Item c - A sketch of a typical whip restraint showing the number and location of the gap elements; include node and element numbers.

Response - An excerpt from Drawing 48W1707-19, showing PD 07-20 from Loop 1, is shown below along with a sketch showing node and element numbers used in the model.





A19-A19
PD07-20
SH 3 & 4

Question 4 - Please provide the following information (continued)...

Item d - Input listings, hard copy output printout and copies of POST plots for the postprocessing runs only.

Response - The POST26 output for the first step of the Loop 1 analysis (from 0.0 to 3.0 seconds) is included as Attachment 4-4, plots are included as Attachment 4-5. The input used to generate this output is included in Attachment 4-1 (Question 4a).

Question 4 - Please provide the following information (continued)...

Item e - The discussion and stress summary sections of the stress report.

Response - The discussion and stress summary for Loop 1 are included in Attachment 4-6.

Question 5 - The response states that "Research and review of published results for comparisons of nonlinear analysis versus testing were performed to verify the propriety and accuracy of the ANSYS model and analysis methods used in the feedwater system assessment." Please provide the published results (or references) that were reviewed. What were the finding of the review? Describe the criteria and/or methodology from the published results that were utilized and demonstrate how they verify the propriety and accuracy of the ANSYS model and analysis methods used.

Response - The assessment that was performed to address the suitability of the ANSYS computer program when applied to the Feedwater Check Valve Slam Analysis covered both verification (program provides accurate results consistent with the programmed algorithms) and qualification (computed results reasonably predict actual behavior).

Verification

The ANSYS Verification Manual (Version 4.4) was reviewed to identify the types of test cases used to verify the specific element types and analyses being used in the feedwater analysis. The element types utilized in the ANSYS model include:

- STIF4 3-D Elastic Beam Element
- STIF16 Elastic Pipe Element
- STIF18 Elastic Elbow Element
- STIF20 Plastic Pipe Element
- STIF60 Plastic Elbow Element
- STIF21 General Mass
- STIF40 Combination Element (used to model non-ductile, or "break away" supports)
- STIF14 Spring-Damper Element (used to model ductile supports)
- STIF52 3-D Interface (gap element used to model whip restraints)

Question 5 - Please provide the following information (continued)...

The analysis type is KAN=4, which is the ANSYS designation for a nonlinear transient dynamic analysis.

From the above list, only the more esoteric program options were addressed in the review including:

- STIF20 Plastic Pipe Element
- STIF60 Plastic Elbow Element
- STIF40 Combination Element ("break away" supports)
- STIF52 3-D Interface (gap element for whip restraints)
- KAN=4 Nonlinear Transient Dynamic Analysis

As shown in Tables 1 and 2, there are a total of twenty-two test cases which utilized the above elements/analysis methods, four of which included one of the above elements in conjunction with the nonlinear transient dynamic analysis option. The four cases demonstrate the verification of the STIF40 element (Combination Element) used to model the supports with a non-ductile failure mode. Each case presents a comparison of ANSYS results with known textbook solutions.

In general, the ANSYS models in the verification test cases are simple, typically consisting of fewer than five elements. The advantage of using simple models is the ability to compare ANSYS results to a closed-form solution.

Qualification - The qualification aspects of ANSYS Computer Program to the WBN feedwater analysis were addressed using an approach similar to the verification aspects. The specifics of the qualification method along with published references are provided in Attachment 5-1. It was concluded that the papers reviewed demonstrate that nonlinear methods can reliably predict the behavior of structures that exhibit nonlinear characteristics.

TABLE 1 - INDEXED BY ELEMENT TYPE

Element Type (1)	Analysis Options (2)	No. Test Cases
STIF20	KAN=0	1
STIF60	---	None
STIF40	KAN=0	1
	KAN=2	4
	KAN=4	4
	KAN=5	6
	KAN=6	5
STIF52	KAN=0	1

TABLE 2 - INDEXED BY ANALYSIS OPTIONS

Analysis Options (2)	Element Type (1)	No. Test Cases
KAN=4	STIF1	2
	STIF3	1
	STIF4	1
	STIF7	1
	STIF8	1
	STIF13	2
	STIF14	1
	STIF21	5
	STIF26	1
	STIF39	1
	STIF40	4
	STIF59	1

NOTES:

(1) The element listed is the primary element type tested; some cases required one or two additional element types (e.g., general mass or elastic beam element) to match the text book problem.

(2) KAN=0: Static
KAN=2: Modal
KAN=4: Nonlinear Transient Dynamic
KAN=5: Linear Transient Dynamic
KAN=6: Reduced Harmonic Response

Question 6 - Provide numerical values and the source(s) for the physical and mechanical properties versus temperature of the material(s) used in the stress analysis. Note that when performing plastic analysis, Appendix F requires that "..the stress-strain curve used shall be included and justified in the Design Report."

Response - Properties used to define the non-linear material curve (S_u, S_y, and E) are described in the response to Question 1.

The coefficient(s) of thermal expansion were taken from Table I-5.0 of the Code. For a change in temperature from ambient (70°F) to 450°F, a value of 7.15×10^{-6} in/in/°F was used for carbon steel (Material Group A, Coefficient B).

Question 7 - During the audit conducted at Watts Bar on November 5-9, 1990, the material properties utilized in the preliminary feedwater check valve slam analysis were reviewed. A Summary of the analysis methodology was subsequently provided by TVA which states that "It should be noted that the material strength obtained from the Code are minimum strength values which are generally very conservative. Therefore, for the elbow attached to the steam generator, the material properties obtained from Certified Mill Test Reports (CMTRs) are used in the analysis. This is done to take advantage of the actual yield and ultimate stresses obtained from the tests for this elbow, which are higher than Code specified values." Were CMTR values used for the mechanical properties of any components in the final analysis and, if so, provide both the CMTR and analysis values utilized. Describe how the analysis values were obtained from the CMTR.

Response - CMTR values were not used in the final analyses. The material properties used are discussed in the responses to questions 1 and 6.

Question 8 - The enclosure states that "The RELAP models were improved to consider simultaneous blowdown of all loops due to the header break (rather than considering one loop at a time ..." In order for the staff to evaluate the adequacy of the regenerated check valve slam force-time histories, provide the basis for concluding that the methodology considering simultaneous blowdown is both conservative and an improvement to the RELAP analysis. Describe the specific improvement(s) achieved.

Response - Revisions to the RELAP model(s)/analysis used to generate the valve slam force-time histories are:

1. <u>Model Scope</u>

   The RELAP model was expanded to include all four FW loops as well as piping upstream of the FW header. This provides a more complete evaluation of the system blowdown by allowing fluid from all loops to simultaneously blowdown through the postulated break(s).

2. <u>Break Locations</u>

   Break locations are compatible with commitments of the FSAR.

3. <u>Check Valve Model</u>

   - Revised valve angle at closure to ensure compatibility with RELAP (which assumes valves are closed at 0°).

   - Mass and moment of inertia of the valve disk were adjusted to ensure compatibility with the following: (1) RELAP limitation of valve disk diameter equal to the pipe diameter (2) ensure that the gravitational force closing the valve is correct while using a moment arm based on the center of pressure.

4. <u>Piping Model</u>

   Inclination of the piping system was changed to 0° (i.e. no slope) to ensure consistency with the REFORCE post processor.

In summary, these enhancements are conservative in that they are more representative of the physical realities of the system.

Question 9 - Enclosure 1 of Reference 3 discusses the preliminary check valve slam analysis; page 3 discusses the loading conditions and states that "Seismic inertial loads are characterized by displacement time histories of the support points; differential movements of support points in adjacent structures are characterized by constant relative displacements of support points superimposed over the inertial displacements." Was this methodology utilized in the final analysis? Please provide a typical example of the application of this methodology and describe how it is implemented in the ANSYS analysis.

Response - Each feedwater loop is supported by three independent structures. Loops 1 and 4 are supported by the RCL (Reactor Coolant Loop/Steam Generator), ICS (internal concrete structure), and ACB (Auxiliary Building). Loops 2 and 3 are supported by the RCL, ICS, and NSV (north steam valve room).

For the final analysis, separate seismic displacement time histories were generated for each support structure. For each structure, three time histories (one for each orthogonal direction) were developed. Within each structure, the three time histories corresponding to the orthogonal directions of motion were imposed on each support point. This is illustrated by the following table:

Support Location	Direction/Time History Number N/S	E/W	Vert.
RCL	1	2	3
ICS	4	5	6
ACB	7	8	9

Relative displacements between structures (i.e. Seismic Anchor Motions's) are inherent in the different time histories used for adjacent structures. The differential displacements between adjacent time histories were compared to, and shown to conservatively envelope, the differential displacements from the building analyses.
The time histories were imposed on the model using tables of time v. displacement generated using the ANSYS Load Step Generator, PREP6. (See ANSYS input, Attachments 4-1 and 4-2.)

Question 10 - In addition to the current nonlinear check valve slam analysis, provide a complete list of design loads, load combinations, and allowable stresses used in the design and analysis of the feedwater lines.

Response - Attachment 10-1 includes copies of the pertinent criteria (piping and supports) which describes the requested information.

Question 11 - Provide the applicable ASME Code Edition and Addenda used for evaluating the stresses in the piping and supports.

Response - Piping criteria and allowables are addressed in question 12a.

Question 12 - Please provide the following information:

Item a - The specific ASME Appendix F criteria (identify by paragraph number) and the calculated numerical values for the allowable. Reference the source of material mechanical properties used.

Response - As listed in the WBN FSAR, criteria was based on the 1980 ASME Code up to and including the Winter 1982 Addenda. Table F-1322.2-1 and F-1324.6 of Winter 82 were applied. Conservatively, maximum stresses were compared to the allowable from F-1341.2(b) of the Summer 82 Addenda:

Material properties are discussed in the response to question 1.

$$P_m \leq 0.7S_u = 45.92\text{ksi}$$

$$P_L = \leq 0.9S_u = 59.0\text{ksi}$$

Item b - Clarify the term "stress" used in the text in the enclosure; note that Appendix F criteria are based on "stress intensity"

Response - The values listed are stress intensities.

Item c - The methodology used to scan the ANSYS output and locate the maximum stress intensities

Response - The ANSYS time history post processor, POST26, was used to scan the results to determine maximum stress intensities.

Question 12 - Please provide the following information (continued):

Item d - A sketch showing the location of the maximum stress intensities and identify the node/elements.

Response - Maximum stresses were in the elbow(s) immediately adjacent to the steam generator. For Loop 1, the maximum stresses occurred in elements 4 and 5 as shown in Attachment 4-3

Item e - The procedure used to classify the "general primary membrane stress intensity" and the "maximum primary stress intensity at any location" from the ANSYS output. Stress limits, if based on Appendix F allowables in F-1341.2, Plastic Analysis, require evaluation for "general primary membrane stress intensity (F-1341.2a) and "maximum primary stress intensity at any location" (F-1341.2b).

Response - Initially, the total calculated stress intensity at each point in the system(s) was classified as general primary membrane stress (intensity), P_m, and compared to the appropriate allowable ($0.7S_u$).

All stresses for Loops 2 and 4 remained below P_m throughout the event.

For Loop 1, total stresses were below P_m for all components except for the elbow closest to the steam generator.

For the Loop 1 elbow, the maximum calculated stress intensity was 52.0 ksi, which exceeds the P_m allowable by ≈13%. A review of the stress time history shows that this maximum value occurs at one of the eight integration points around the circumference of the pipe, and at one location along the length of the elbow (i.e. at one point in the model). When this maximum value occurs, all other stresses are below the P_m allowable. Since the point at which the stress exceeds the P_m allowable is isolated in time and space, the stress is considered representative of a local effect. Because the stress is much below the primary local membrane allowable (P_L) of $0.9S_u$, it is considered acceptable.

Question 12 - Please provide the following information (continued):

Item f - The source of the stresses quoted in the first two paragraphs on page 4. The first paragraph states "The maximum stress in that elbow was 52.0 ksi: and the second paragraph states "the maximum stress at any point was 48.4 ksi."

Response - The first paragraph refers to the maximum stress at any point in time. (Please refer to response to Item e - 52.0 ksi). When this stress occurs, stresses at all other points in the model are below the P_m allowable.

The second paragraph describes the only point in time when the P_m is exceeded at more than one geometric location. During a period of 4-milliseconds, stresses are greater than the P_m allowable at one circumferential point at on end and at the midpoint of the elbow. During this 4-millisecond time period, the maximum stress at the end of the elbow is 48.4 ksi and maximum stress at the midpoint of the elbow is 47.3 ksi. These values exceed the P_m allowable by 5.3% and 3.0%, respectively.