Docket No. 52-001 September 14, 1992

APPLICANT: GE Nuclear Energy (GE)

PROJECT: Advanced Boiling Water Reactor (ABWR)

SUBJECT: AUDIT SUMMARY - ABWR PIPING DESIGN

The Nuclear Regulatory Commission staff (staff) conducted an audit on the GE ABWR piping design on July 28 - 31, 1992, at the GE offices in San Jose, California. The enclosed Audit Trip Report provides a summary of audit findings.

From a total of 31 open issues, this audit resolved 13 issues, partially resolved 4 issues, and the staff and GE reached agreement on 9 issues, pending confirmation by SSAR revision. In addition, the staff discussed with GE comments from the Greybeard Committee concerning generic piping design inspections, tests, analyses, and acceptance criteria (ITAAC).

A preliminary position concerning environmental effects on piping fatigue was reached by GE and the staff which will be presented at the next Pressure Vessel Research Council meeting in October 1992.

(Original signed by)
Rebecca L. Nease, Project Manager
Standardization Project Directorate
and License Renewal
Associate Directorate for Advanced Reactors
Office of Nuclear Reactor Regulation

Enclosure:
Audit Trip Report

cc w/enclosure:
See next page

DISTRIBUTION:

Central File	PDST R/F	TMurley/FMiraglia	DCrutchfield
NRC PDR	RPierson	JNWilson	CPoslusny
VMcCree	RNease	PShea	JMoore, 15B18
EJordan, 3701	ACRS (10)	GGrant, EDO	THiltz
TBoyce	DTerao, 7H15	SHou, 7H15	

OFC:	LA:PDST:ADAR	PM:PDST:ADAR	SC:PDST:ADAR
NAME:	PShea	RNease:tz	JNWilson
DATE:	09/11 /92	09/14/92	09/14 /92

OFFICIAL RECORD COPY: DOCUMENT NAME: AUDITSUM.RN

9209240382 920914
PDR ADOCK 0520000
A PDR

cc: Mr. Patrick W. Marriott, Manager
Licensing & Consulting Services
GE Nuclear Energy
175 Curtner Avenue
San Jose, California 95125

Mr. Robert Mitchell
General Electric Company
175 Curtner Avenue
San Jose, California 95114

Mr. L. Gifford, Program Manager
Regulatory Programs
GE Nuclear Energy
12300 Twinbrook Parkway
Suite 315
Rockville, Maryland 20852

Director, Criteria & Standards Division
Office of Radiation Programs
U. S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Mr. Daniel F. Giessing
U. S. Department of Energy
NE-42
Washington, D.C. 20585

Mr. Steve Goldberg
Budget Examiner
725 17th Street, N.W.
Room 8002
Washington, D.C. 20503

Mr. Frank A. Ross
U.S. Department of Energy, NE-42
Office of LWR Safety and Technology
19901 Germantown Road
Germantown, Maryland 20874

Mr. Raymond Ng
1776 Eye Street, N.W.
Suite 300
Washington, D.C. 20006

Marcus A. Rowden, Esq.
Fried, Frank, Harris, Shriver & Jacobson
1001 Pennsylvania Avenue, N.W.
Suite 800
Washington, D.C. 20004

Jay M. Gutierrez, Esq.
Newman & Holtzinger, P.C.
1615 L Street, N.W.
Suite 1000
Washington, D.C. 20036

Mr. Mark McCabe
U.S. Dept. of Justice/EAG
555 4th Street, N.W.
Room 11-809
Washington, D.C. 20001

Mr. Joseph Quirk
GE Nuclear Energy
Mail Code 782
General Electric Company
175 Curtner Avenue
San Jose, California 95125

Enclosure

AUDIT TRIP REPORT

PURPOSE: Audit of the GE Advanced Boiling Water Reactor (ABWR) Piping Design Criteria and Sample Analyses

LOCATION: GE Nuclear Energy, San Jose, CA

DATES: July 28-31, 1992

NRC PARTICIPANTS: D. Terao (NRC), S. Hou (NRC), R. Nease (NRC), P. Bezler (BNL), G. DeGrassi (BNL), J. Braverman (BNL), K. Jaquay (ETEC), and W. Shack (ANL)

GE PARTICIPANTS: J. Fox, M. Herzog, E. Swain, H. Hwang, and others (see Attachment 1)

The purpose of this audit was to complete the review of the General Electric (GE) proposed piping design criteria and sample analyses for the Advanced Boiling Water Reactor (ABWR). This was a follow up to the NRC audit conducted in March, 1992.

The audit agenda, which is included as Attachment 2, covers the main areas of discussion and review. One of the main objectives of this audit was to close out staff concerns raised during the first audit. A total of 31 audit concern sheets had been prepared to describe the issues. Just prior to this audit, GE submitted their written responses to each concern and the audit team prepared preliminary evaluations. During the audit, each issue was discussed in detail with GE technical personnel. Significant progress was made in resolving the concerns. By the end of the audit nearly three quarters of the open issues were either closed or closed subject to an agreed upon confirmatory action (such as an SSAR revision). However, eleven items remain open. Although there was general agreement on the actions needed for closure, more GE efforts were suggested for timely input to the staff final SER. Attachment 3 includes the audit team conclusions on each of the 31 audit concerns as well as a summary of the current resolution status.

One of the open issues discussed during the audit was the GE procedure to account for environmental effects in the fatigue evaluation of piping. Recent test data indicates that a BWR environment may significantly reduce the fatigue resistance of certain materials. For the affected materials, the margins in the ASME Code fatigue curves may be less than originally intended. GE and the NRC consultant from ANL discussed this issue in detail and worked out a preliminary interim procedure which is summarized in

Attachment 4. The procedure involves supplementary fatigue analysis of selected piping components for environmental effects using ANL fatigue curves, adjustment of fatigue curves for the effects of transient strain rates and temperature changes, and fracture mechanics evaluation for components in which the supplementary fatigue evaluation indicates a cumulative usage factor greater than one. This preliminary procedure will be further reviewed by the staff and will be presented at the next PVRC meeting in October for discussion.

The audit team and GE also discussed the open issues identified in the NRC draft safety evaluation report (SER) on the ABWR piping. There was significant overlap between these issues and the 31 audit concern issues. Based on these discussions, necessary SER and SSAR revisions were identified as well as required GE actions. The results of the discussions will be summarized in the final SER.

The preliminary results of the BNL confirmatory analysis of the GE sample piping problems were discussed. BNL had analyzed the Feedwater line and the SRV wetwell line using the PSAFE2 program to verify the results of the GE PISYS program analysis. Comparisons of Feedwater line response spectra analysis results and of SRV wetwell time history and response spectrum analysis results showed significant differences. The results of the BNL analyses were sent to GE prior to the audit. GE was asked to review both their analyses and the BNL analyses and attempt to identify the causes for the differences. GE provided the following information at the audit:

1. Feedwater Line Response Spectrum Analysis:

   GE determined that their analysis had inadvertently used a file with incorrect mode shapes and participation factors. They reran the analysis with the correct input and saw generally better agreement with BNL results. In reviewing the BNL input, GE found a small error in a section property. The 12 inch pipe OD had been input as 12.359 inches instead of 12.539 inches. BNL agreed to make this correction in the PSAFE2 input and rerun the problem. GE will provide the full output of their revised analysis for the final comparison.

2. SRV Wetwell Line Time History Analysis:

   The GE direct integration time history analysis had used a time step of 0.007 seconds. When BNL analyzed the problem with the same time step, the results were significantly different. BNL reduced the time step and found that the results changed by more than 10%. The results of the BNL analysis converged using a time step of 0.0005 seconds. However, these results still did not agree with the GE results. GE agreed to run the analysis with smaller time

steps. Their results were presented at the audit. With the 0.0005 time step, GE saw significant differences in certain responses compared to their original analysis. There was also generally better agreement with the BNL results. GE also noted that their analysis used hot material properties (modulus of elasticity) while BNL used cold properties. BNL agreed to rerun the analysis with the hot properties for final comparison.

3. SRV Wetwell Line Response Spectrum Analysis:

GE found that they had incorrectly used 5% damping in their double sum modal combination method instead of 2% damping. GE reran the analysis with the correct damping and showed a better comparison with BNL results. GE also ran a case with SRSS combination and found the results more closely matched the BNL results which were based on the 10% grouping method. BNL will perform an additional analysis using a consistent modal combination method.

4. NRC Benchmark Problem 2:

Prior to the audit, GE was asked to run NRC Benchmark Problem 2 from NUREG/CR-1677 Vol. II using their current version of PISYS for comparison with a BNL analysis of the same problem using the current version of PSAFE2. GE presented the results at the audit. However, due to a misunderstanding, they ran a different problem (problem 2 from NUREG/CR-1677 Vol I). BNL agreed to provide the PSAFE2 input for this problem to GE for their reanalysis.

ATTACHMENT 1

AUDIT MEETING ATTENDEES

NRC ABWR PIPING AUDIT

San Jose, California

August 28, 1992

NAME	ORGANIZATION
David Terao	NRC
Shou-nien Hou	NRC
Jack Fox	GE
Sam Ranganata	GE
Maryann Herzog	GE
Ed Swain	GE
Joseph Braverman	BNL
Bill Shack	BNL
Giuliano DeGrassi	BNL
Paul Bezler	BNL
Ken Jaquay	ETEC

ATTACHMENT 2

AUDIT AGENDA

NRC Audit of GE on

ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES

July 28-31, 1992

AGENDA

I. Discuss GE response to staff concerns with respect to piping system stress analysis identified in last audit, which was performed at GE's office in San Jose, California on March 23-26,1992.

2. GE to provide methods and sample analyses for high energy line break. Calculations for the Feedwater line breaks may be used.

3. Discuss open issues identified by the staff in the draft report containing preliminary safety evaluatin of the ABWR piping design.

4. Discuss tentative findings of staff review on the GE sample analyses of ~~three~~ ABWR piping systems. Status of independent confirmatory analysis performed by the NRC consultant, the Brookhaven National Laboratory will be presented.

5. Discuss details concerning application of piping benchmark program to future ABWRs for verifying acceptability of computer codes and approaches used in piping analysis.

6. Discuss followup actions needed by GE and the staff to complete final safety determination or ABWR piping design.

ATTACHMENT 3

AUDIT CONCERN SHEETS

AUDIT CONCERN SHEET
STATUS SUMMARY
(7/31/92)

CLOSED ITEMS:	1, 2, 4(1), 7, 11, 12, 13(1), 13(3), 14, 15, 16 19, 20(3), 20(4), 21, 22, 23, 24, 27
CLOSED/CONFIRMATORY ITEMS:	3, 5, 10, 20(1), 20(2), 26, 28(A), 28(B), 29, 30, 31
OPEN ITEMS:	4(2), 6, 8, 9, 12(2), 12(3), 13(2), 17, 18, 25, 28(c)

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: 1 By: _____

DESCRIPTION OF CONCERN:

Request a list of procedures for analysis methods / criteria for piping and piping supports. Then, copies of selected procedures will be requested.

RESPONSE BY GE:

The NRC/CNL requested ~~the~~ a list of documents / information during the audit GE has agreed to provide all items except the Design Record Files and the detailed internal design procedures. These 2 "excepted" items are available for audit / review / discussion in GE - San Jose and will be made available in GE - Bethesda, but the material may not be copied nor removed. Copies of the other requested items will be forwarded to the NRC.

STAFF EVALUATION:

All documents GE agreed to provide have been received. We will need to review the internal procedures (which GE did not provide) to determine whether they are complete and adequate.

CONCLUSION:

Closed: we do not need to review internal procedures but we expect all relevant information to be included in SSAR. Specific areas of review are discussed in other audit evaluation sheets

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: 2.

By: _____

DESCRIPTION OF CONCERN:

Request 1) R cover spectra for seismic and other loads
2) References in Criteria Doc.
3) SSAR 3.7, 3.9, & applicable figures (e.g. reactor bldg. floor envelope)
4) Model input data including floppy disk & load cycle/temp. diag. for all 3 sample piping systems.

RESPONSE BY GE:

This item is addressed in Item No. 1.

STAFF EVALUATION:

All of this information was received by BNL.

CONCLUSION:

Closed

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: 3

By: _____

DESCRIPTION OF CONCERN:

A discrepancy exists in SSAR Table 3.2-1 for the SRV piping regarding piping classification of 2/3 versus ~~Class 3~~ specified elsewhere in the SSAR.

RESPONSE BY GE:

GE concurs with NRC/BNL's finding. This discrepancy was also identified by GE in a recent engineering review of the SSAR. GE will ~~make~~ modify sections 3.9.3.1.13 and note h of Table 3.2-1 of the SSAR to properly reflect the classification of the SRVDL piping and to be consistent within these applicable sections.

STAFF EVALUATION:

Response is acceptable. GE should make modifications to SSAR available for review.

CONCLUSION:

Closed / confirmatory: subject to acceptable SSAR modifications

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO: A-4

DESCRIPTION OF CONCERN:

1. What is the ASME classification of the SRV quencher?

2. What analysis and design method was used relative to its design specification?

RESPONSE BY G.E.:

1. Response prepared by JB Knepp

2. The quencher is analyzed to the rules of ASME-III, Class 3. The quencher is treated as a fabricated assembly of piping components and is analyzed to the rules of ND-3600. The analytical methods are described in the summary stress report and in supporting documents such as:

Containment Loads Report, Specification No. A21-2040;
386HA579, Dynamic Load Methods and Criteria;
Computer Manual for PYSIS.

See next page

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: 4 By: _____

DESCRIPTION OF CONCERN:

What is the ASME classification of the SRV quencher and what analysis and design method was used relative to its design classification?

RESPONSE BY GE:

Consistent with Table 4, the MSSR quencher will be classified as ASME Class 3.

STAFF EVALUATION:

GE shall explain why the quencher classification is not consistent with attached pipe which is Class 2.

CONCLUSION:

Item 1): Closed

Item 2): Open: GE to review GESSAR and decide on what method of analysis will be used to evaluate for fatigue

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: 5 By: _____

DESCRIPTION OF CONCERN:
Why are both ASTM and ASME designation presented in Criteria Document ? - Implies could be bought to ASTM.

RESPONSE BY GE:
The ASTM designation will be removed from the Criteria Document, thereon invoking the ASME material requirements.

STAFF EVALUATION:
Response is acceptable. GE should provide revised Criteria document for review

CONCLUSION:
Closed/confirmatory: subject to SSAR revision and review

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO: A-6

DESCRIPTION OF CONCERN:

1. Need to see criteria for all supports - analysis/design.
2. SSAR needs to include description/requirements for guides.

RESPONSE BY G.E.:

1. There is no single E document that sets forth all the criteria for the design/analysis of supports. The SSAR covers all pipe supports in considerable detail, with the possible exception of the Main Steam/Feedwater guides and structural frame supports such as those in the wetwell. The most important documents defining design/analysis criteria are the G.E. pipe suspension purchase specifications and the pipe suspension drawings. These documents: (1) Provide a complete basis for design, manufacture, qualification, examination and installation of pipe supports for all ASME III piping; Require the design and analysis of supports for nuclear piping to be in conformance with NF Subsection of ASME III and suports for non-nuclear piping to be in conformance with ANSI B31.1; and (3) Provide design loads obtained from the piping analysis and specify the minimum support stiffness, allowable materials, installation tolerances.

Examples of recent documents prepared for the K6/K7 plants are:

23A6061 - Main Steam, Feedwater & Safety/Relief Valve Discharge Pipe Suspension.
103E1512 - Main Steam Pipe Suspension
103E1437 - Feedwater Pipe Suspension
103E1525 - SRV D/W Pipe Suspension
103E1526 - SRV W/W Pipe Suspension

2. G.E. is now considering adding additional requirements to the SSAR to provide more detail on the main steam and feedwater guides inside containment.

See next page.

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: 6 By: _____

DESCRIPTION OF CONCERN:

1) Need to see criteria for all support - analysis/design.
2) SSAR needs to include description/requirements for guides

RESPONSE BY GE:

2) GE concurs with this comment and will include the requested information in a future amendment of the SSAR. Additionally, information on "other" supports (e.g. energy absorbers) will be added to the SSAR so that use of these "other" support is not precluded.

STAFF EVALUATION:

1) We need to review the referenced documents for adequacy
2) GE should clarify their commitment on this issue. In addition, their response should not be limited to the main steam and feedwater lines.

CONCLUSION:

Open: GE needs to provide additional information on support analysis/design in SSAR as discussed during audit (e.g., support stiffness, friction coefficients, gap requirements, anchor bolt safety factors, deflection limits, etc.)

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
MARCH 21-27

ITEM NO: A-7

DESCRIPTION OF CONCERN:

Why does the Piping Criteria document utilize only Reference 6.0-c and not all applicable NRC R.G.'s and S.R.P's ?

RESPONSE BY G.E.:

All applicable NRC R.G's and S.R.P's will be referenced in the Piping Criteria document.

STAFF EVALUATION:

Response acceptable. GE should provide revised document for review

CONCLUSION: Closed; referenced in SSAR

ITEM NO: A-8

DESCRIPTION OF CONCERN:

The 1/3 pipe size criteria is not sufficient, additional piping decoupling/interaction criteria(e.g. SSAR 3.7.2.3.1) are needed. The effect of branch line supports close to the main line should be considered.

RESPONSE BY G.E.:

The criteria specified in Section 3.7.2.3.1 of the SSAR are used to determine whether a piping or equipment subsystem can be decoupled from the Building or primary system model. If the diameter of the branch line is less than 1/3 the diameter of the main line, it can be decoupled from the main line.

For a decoupled branch line, no dynamic supports will be located close to the main line. Otherwise the adjacent support would be loaded by the main line during dynamic events.

STAFF EVALUATION

The concern was not fully addressed. GE should provide the technical basis for the 1/3 ratio. GE should also provide a measurable criterion on how close the branch line supports may be located to the main line. The technical basis for the criterion should also be provided. Also, a description of how branch line mass is considered in a

Item A-8 (continued)

CONCLUSION:

Open: GE to resolve their damping criteria and include in SSAR

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO: A.9

DESCRIPTION OF CONCERN:

Request criteria document(s) discussing dynamic analysis criteria in more detail (e.g. basis for highest frequency of interest, damping, delta t for time history analyses, ISM method of analysis, modal analysis method, how is the "effective/weighted" modal damping determined.

RESPONSE BY GE:

Document 386HA579, Dynamic Load Methods and Criteria, by DK Henrie, provides the best available details on the dynamic methods and criteria used by GE in the dynamic analysis of piping. A copy of this document was provided during the March meetings. Based on verbal comments, it is GE's understanding that the 386HA579 document was satisfactory response to this item.

STAFF EVALUATION

Response is acceptable. The document was made available. We need to complete our review to determine whether it is adequate

CONCLUSION:

Open: GE has to resolve a number of issues and include in SSAR (e.g. 100 Hz cutoff frequency, damping for direct integration analysis, Δt for time history analysis, time history breakdown, ISM method weighting, etc). BNL needs to identify items that should be in SSAR.

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
March 23-27, 1992

Item No.: A10 By: _____

DESCRIPTION OF CONCERN:

Are forcing function variations considered for direct integration analysis due to hydrodynamic loads. This variation (expansion and contraction) of the forcing function is the equivalent of response spectra peak broadening.

RESPONSE BY GE:

The wetwell loading input has been defined to cover all frequency ranges (similar purpose of expansion and contraction). Some time history loads are impulse type loads, such as safety relief valve discharge loads, expansion of the time history is equivalent to increasing the load. It is not necessary to add extra conservatism to this type of load. Similarly, it is not appropriate to contract the load (equivalent to reducing the load).

STAFF EVALUATION:

~~CONCLUSION:~~

GE should provide more specific information to demonstrate how the loading input has been defined to address the stated concern.
For impulse type loads, GE should provide the basis for concluding that their load definition is sufficiently conservative to account for variation in analysis parameters.

CONCLUSION:

Closed / Confirmatory: GE needs to revise SSAR and provide typical justification for deviations.

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO: A-11

DESCRIPTION OF CONCERN:

Clarify definition of components vs. damping values (snubber&strut) in damping table presented in the Piping Criteria document.

RESPONSE BY G.E.:

The following note will be added to Table 1 : (in the Piping Criteria doc.)
Snubbers and Struts are connected to the piping and to the supporting structure with pin connections, therefore the R.G. 1.61 damping values for bolted steel structures are used. Piping test data results show that the damping values for struts are at least equal to those for bolted structures, and the damping values for snubbers are greater than those for bolted structures.

STAFF EVALUATION
Response is acceptable

CONCLUSION
Closed

ITEM NO.: A-12

DESCRIPTION OF CONCERN:

1. Provide the basis for application of all displacements in the same direction.

2. Provide justification for SRSS combination of inertia and displacement effects.

3. Provide criteria for order of combination for inertia and displacement loading events.

RESPONSE BY G.E.:

1. An additional seismic displacement case will be evaluated in which it is assumed that the biological shield wall moves in a direction opposite to the reactor pressure vessel and the drywell wall. Because the seismic inertia loads are so high there will be no significant change in the calculated piping stresses or support loads.
2. "The inertia(primary) and displacement(secondary) stresses are dynamic in nature and their peak values are not expected to occur at the same time. Hence combination of the peak values of inertia stress and anchor displacement stress is quite conservative. In addition, the anchor movement effects are computed from static analyses in which the displacements are applied to produce the most conservative loads on the components. In view of this, the combination of primary and secondary stresses shall be by SRSS."

Referenced from GE doc. no. 386HA579, Rev. 0

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AMD SAMPLE ANALYSIS
ON MARCH 23-27

ITEM NO: A-12(continued)

RESPONSE BY G.E.:

3 Since all dynamic loads are combined by the SRSS method, the order of combination of inertia and displacement loads does not effect the results. The calculated dynamic loads are then combined with thermal and weight loads either by algebraic summation or by the absolute sum method.

STAFF EVALUATION

1) GE did not address the general concern. Analytical procedures should be revised to ensure that displacements are imposed in the most unfavorable direction as required by SRP 3.7.3

2) Per SRP 3.7.3, support displacements should be added to inertia using the absolute sum method.

3) If absolute sum method is used, the order of combination will effect the results

CONCLUSIONS

1) Closed: procedure described in SSAR

2)+3) Open: GE will provide a writeup to justify their method

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO: A-13

DESCRIPTION OF CONCERN:

1. Interaction concern: flexibility of building local structure affecting/amplifying floor response spectra
   How is this addressed? (e.g. floor flexibility)

2. Piping amplified spectra for branch line analysis, How is this addressed?

3. Provide justification for the 1.2 factor for hydrodynamic amplification to account for local flexibilities

RESPONSE BY G.E.:

1. Flexibility of building local structures, such as steel platforms used for supporting piping and other equipment, are accounted for in the piping analysis. For the sample problem it was assumed that the steel platform has a fundamental frequency greater than or equal to 33 hz Therefore, there is no amplification of the seismic loads. For hydrodynamic loads, a dynamic amplification factor of 1.2 was used. This factor is necessary to account for amplification at frequencies greater than 33 hz.

2. For branch lines decoupled from the main line, amplified spectra are applied at the attachments to the main line. The ERSIN computer program is used to generate the amplified response spectra.

3. The 1.2 factor was calculated and used in the analysis of the ABWR's under construction in Japan.

STAFF EVALUATION

1) GE should provide additional information and calculations to show how the 1.2 factor was determined

2) Response is acceptable. We should review adequacy of ERSIN computer program

3) Calculation should be provided (see item 1 above). GE should also provide the general procedure on how amplification factors are determined and when they should be applied

Item A-13 CONCLUSIONS: 1) Closed: to be reviewed by NRC structural group
2) Open/GE to provide SSAR write-up as part of decoupling criteria
3) Closed: to be reviewed by NRC structural group

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
ON MARCH 23-27

ITEM NO: A-14

DESCRIPTION OF CONCERN:

1. How many cycles will be used for seismic and other loads?
2. What is the basis for using ½ SSE floor spectra for OBE floor spectra?
3. Were building rocking effects added to the vertical spectra?

RESPONSE BY G.E.:

1. The SSAR and the Piping Criteria document will be revised to specify the correct number of cycles. In Table 3.9-1 of the SSAR, the number of events or cycles will be increased by 50 % for the following events: Events 1- 9 and Events 14&15.
2. There is no basis for using ½ sse floor spectra for OBE floor spectra. This was done because the OBE floor spectra were not available. The Piping Design Criteria document will state that for future analysis of ABWR piping, the appropriate OBE floor response spectra shall be used in the analysis.
3. Building rocking effects were not added to the vertical spectra. This was determined to be unnecessary since there was adequate conservatism in the structural analysis.

STAFF EVALUATION

1) & 2) Acceptable 3) Needs review by NRC structural audition

ITEM NO: A-16

DESCRIPTION OF CONCERN: CONCLUSION

Closed: to be reviewed by NRC structural group

How and why is the flooded load included in the analysis?
How many cycles are considered?

RESPONSE BY G.E.:

Two hydrostatic test cycles are considered for each boltup cycle. Therefore 135 events are considered to occur during the 60 year design life. During the hydrostatic test event, the main steam line and the SRV discharge lines are filled with water. Therefore for these lines a dead weight analysis is done for these lines filled with water.

STAFF EVALUATION CONCLUSION

Response is acceptable Closed

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO: A-15

DESCRIPTION OF CONCERN:

1. How do you insure SRV valve to be purchased will have a rise time greater than 20 msec?

2. Same applies to TSV.

RESPONSE BY GE:

1. GE has not placed any restrictions on how fast the safety-relief valves may open or on how rapidly the turbine stop valves may close. The specification for the Safety-Relief Valve requires the "Total elapsed time from start of main disk motion to full stroke of the SRV (i.e., lift to full rated capacity position) shall not exceed 0.15 seconds." GE calculates the forcing function for RV-1 based on a 20 millisecond rise time. Rise time is defined as the period of time from start of flow through the valve until essentially full flow. G.E. has established the 20 milliseconds as a conservative valve based on evaluation of available data from valve manufacturers.

The results of the overall analytical process includes many important variables, including: analytical model of pipe and supports (stiffness, wall thickness, diameters), the analytical assumptions in the computer program RVFOR, out-put time step, steam line pressure, total FL/D and inside diameter of discharge pipe, analytical definition of quencher, code method for calculating stresses at branches and elbows.

G.E. does not feel is necessary, nor desirable, to upper bound all the variables in the analytical process. It is important the overall analytical process give results that are in satisfactory agreement with actual test results. G.E. has performed numerous in-plant tests which have shown the overall analytical procedure for calculating stresses gives reasonable results compared with stress measured.** There is no data to indicate the stress valves calculated by G.E. analytical methods are nonconservative.

In addition, the Start-Up testing program for each BWR requires strain gauge instrumentation be install on typical SRVD lines and SRV inlet piping to confirm, on a plant by plant bases, the analysis gives results in satisfactory agreement with measured results.

2. The philosophy described above also applies to the TSV load.

**

Note: (1) Special in-plant tests performed at Duane Arnold, Monticello, Kuosheng and Coarso.

(2) Special SRV test at Wiley Laboratories facilities at Huntsville, Alabama under direction of H.L. Hwang.
(3) NEDE-23751, BWR/6 Mark III Safety/Relief Discharge Piping Transient Force Parametric Study, Dec. 1977. "Based on test data, the shortest opening time is 0.02 second. It is conservative to assume a short opening time."
(4) HL Hwang Studies:
Letter to E.O. Swain, February 14, 1978, SRV Opening Time.
Letter to H.Chang, dated November 9, 1976, Preliminary Monticello SRV Discharge Test Results, SRV Piping.

STAFF EVALUATION

Response appears acceptable. However, GE should confirm that the ABWR start up test program will include strain gage instrumentation on SRV [illegible] to confirm that the analysis gives reasonable results.

CONCLUSION

Closed: (per SER write-up)

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO: A-17

DESCRIPTION OF CONCERN:

1. Will GE consider/perform fatigue evaluation for thermal effects when piping involves hot and cold thermal mixing?

2. Provide thermal stratification criteria/methodology for piping analysis.

RESPONSE BY GE:

1. It is GE practice to evaluate the thermal stresses in piping at locations where hot and cold liquid streams are mixing. The normal procedure is to assume the temperature of points in the piping in the vicinity where the mixing occurs will fluctuate rapidly between the hot temperature and cold temperature of the two mixing streams. It is further assumed a large number of thermal cycles between the hot and cold temperatures will occur in a short period of time. Therefore the thermal stresses must be will below the endurance limit of the material. If calculations show the thermal stresses approach or exceed endurance limit values, GE requires a thermal sleeve be designed and installed to protect the pressure boundary from fatigue damage.

2. By KFF

STAFF EVALUATION

GE needs to expand on how thermal stresses will be calculated. Will Class 1 or Class 2 calculations be performed? How will endurance limit be determined? Also, GE did not respond to question on which systems requiring this evaluation should be specified now (p 3.9-45 of SSAR).

CONCLUSION

1) Open: GE to provide a SSAR writeup describing a ΔT screening criteria to be applied to determine if fatigue analysis is necessary

ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
March 23-27, 1992

Item No.: A17

By: _____

DESCRIPTION OF CONCERN:

1. Will GE consider/perform fatigue evaluation for thermal effects when piping involves hot and cold thermal mixing? See p. 3.9-45 of SSAR - should systems requiring this evaluation be specified now?

2. Provide thermal stratification criteria/methodology for piping analysis.

RESPONSE BY GE:

1. By EOS

2. The thermal stratification load is caused by different temperatures at the top and bottom of a horizontal pipe. The loads and stresses caused by thermal stratification are similar to those caused by thermal expansion. Therefore, the stresses and load criteria for thermal stratification should be combined with concurrent thermal expansion stresses and loads by algebraic summation. The combined results should meet the thermal expansion limits specified by ASME Code. The analysis method is described in an internal GE document (ABWR-88027).

STAFF EVALUATION:

2) Response appears acceptable. We need to review the referenced GE document.

CONCLUSION:

2) Open: GE to provide a SSAR writeup on thermal stratification analysis method + criteria

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27,1992

Item No.: 18

By: _____

DESCRIPTION OF CONCERN: (considering)
Provide criteria and basis for environmental effects for fatigue evaluation.

RESPONSE BY GE:

GE will provide the three items addressed by Dr. Rangaraja during the audit:
(1) Appendix 50 of 22A7014, "Materials and Processes Controls", "Fatigue Crack Orientation Design Rules for Carbon Steel"; (2) PVRC Presentation slides "Fatigue Tests of CS in High Temp. Oxygenated Water"; (3) W.E Cooper paper "The Initial Scope & Content of Section III Fatigue Design Procedures".

STAFF EVALUATION:

GE provided the documents. SNL needs to complete the review

CONCLUSION:

Open: NRC staff to consider proposed interim methodology

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANLYSIS
ON MARCH 23-27

ITEM NO: A -19

DESCRIPTION OF CONCERN:

How is the damping value determined for piping systems which include small and large diameter piping?

Provide procedures to determine damping for both ISM and USM methods of analysis. Provide justification for methodology.

RESPONSE BY G.E.:

Independent Support Motion (ISM) Damping Values:

For each response spectrum used, the damping value corresponds to the pipe size at the support. Therefore, in an ISM response spectra analysis more than one damping value can be used.

Uniform Support Motion (USM) Damping Values:

For each response spectrum used to generate the enveloped response spectrum, the accelerations correspond to a damping value dependent on the pipe size at that support. Once the enveloped response spectrum is generated, the smallest damping is then used in the dynamic analysis.

These are the typical industry practices. For the USM method the use of the smaller damping values in the dynamic analysis is conservative.

STAFF EVALUATION

ISM damping appears acceptable. GE needs to clarify USM damping response. Is the enveloped spectra an envelope of spectra with potentially different damping values? If so, how is the smallest damping used in the dynamic analysis

CONCLUSION

Closed

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
ON MARCH 23-27

ITEM NO: A-20

DESCRIPTION OF CONCERN:

1. In the Criteria document, clarify the description of the RV2 load and specify any factors used in the RV2 analysis.

   Does SRV all valve bound all RV2 loads?

2. Functional/Operability requirements per S.R.P. 3.9.3 are not in the GE Criteria document.

3. Load combinations for Equation 10 & 11 are not in the Criteria Doc.

4. What revisions will be made to the Tables in the Criteria document?

RESPONSE BY G.E.:

1. The description of all RV2 loads and all applicable factors will be included in the Criteria document. SRV all valves does bound all RV2 loads.

2. & 3. These items will be included in the Criteria document.

4. Tables 3 & 4 will include primary and secondary load combinations. Table 3 will specify that the lesser of two acceptance criteria shall be used, a note will be added on functional capability criteria.

   Tables 3,8,9,11,12,13&14: Individual loads will be separated by commas instead of +'s.

   Table 12: Allowable moments will be deleted, acceptance criteria will specify the applicable ASME Code paragraph.

   Table 9: The acceptance criteria will be specified.

   Table 13: Acceptance criteria will be deleted.

STAFF EVALUATION

Response appears acceptable. GE should provide revised criteria document for final review

CONCLUSIONS:

1) Closed/Confirmatory: GE to revise SSAR to 3.9-1 to include SRV load breakdown

2) Closed/Confirmatory: GE to put in level D stress limits for operability into SSAR

3) & 4) Closed

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
ON MARCH 23-27

ITEM NO: A-21

DESCRIPTION OF CONCERN:

Provide BWR 6 Load Combination definitions

RESPONSE BY G.E.:

G.E. Document No. 386HA931, Rev. 2, Event Combinations and Acceptance Criteria, provides the BWR 6 LOad combinations.

STAFF EVALUATION

Document has been received. We need to review

CONCLUSION: Closed

ITEM NO: A-23

DESCRIPTION OF CONCERN:

Provide description and bases of spectra interpolation/extrapolation procedure (for different elevations/locations).

RESPONSE BY G.E.:

GE internal procedures provide guidelines on response spectra selection. The RINEX computer program is used to interpolate and extrapolate response spectra.

CONCLUSION: Closed

STAFF EVALUATION

GE needs to expand on the response. The method for spectra interpolation/extrapolation was not described. We may need to review internal procedures and RINEX program

ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
March 23-27, 1992

Item No.: A22 By: _____

DESCRIPTION OF CONCERN:

Does GE intend to use ASME Section 3200 related to plastic analysis method. If so, provide criteria since the Code lacks requirements in certain areas.

RESPONSE BY GE:

It is not GE's intent to use ASME NB-3200 plastic analysis as a generic method. such as limit analysis, to meet the primary stress allowables. There are two possible applications: (a) calculate the plastic strain for fatigue usage evaluation, and (b) pipe whip restraint analysis due to a postulated pipe break. The present Code requirements are adequate for these two applications.

STAFF EVALUATION:

GE should state whether they intend to use plastic analysis in these applications and, if so, provide procedures

CONCLUSION:

Closed: GE will not use plastic analysis method

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO. A-24

DESCRIPTION OF CONCERN:

1. What is the method of seismic analysis for the main steam piping beyond isolation valve outside containment to turbine building.

2. If dynamic analysis will be used, then what document provides the seismic spectra input.

RESPONSE BY GE:

1. Main steam piping between containment and the turbine building will be analyzed for seismic loads using response spectra methods and code allowables equivalent to that applied to ASME Class 3, piping.

2. The seismic spectra input has not yet been defined. This subject is still under study by GE and under negotiation with the NRC.

STAFF EVALUATION

Response appears acceptable. Seismic spectra subject to final approval by NRC

CONCLUSION

Closed: To be reviewed by NRC structural group

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
ON MARCH 23-27

ITEM NO: A -25

DESCRIPTION OF CONCERN:

Why does piping analysis use ZPA for high frequency effects, rather than the acceleration at the highest frequency at which the modal analysis ends?

RESPONSE BY G.E.:

The acceleration at the analysis cut-off frequency should be used to calculate the high frequency effects.

STAFF EVALUATION

Response is acceptable but criteria/methodology document should be revised to clarify this.

CONCLUSION

Open: GE to provide a write-up justifying use of ZPA

CONCLUSIONS:

Closed / Confirmatory: GE to revise SSAR to state that all underground and exterior piping will be housed in tunnels

NRC AUDIT OF GE ON
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
MARCH 23-27

ITEM NO: A-26

DESCRIPTION OF CONCERN:

1. What are the analysis/methodology and acceptance criteria for buried piping analysis (beyond short descriptions in SSAR)?

2. What provisions are provided for protection from external events (e.g. wind, tornado, missiles? If no protection is provided for some of the events, what are the analyses/methodology and acceptance criteria?

RESPONSE BY GE:

1. GE ~~will~~ has not yet determined if the SSAR should be revised to provide more definition of analysis methods to be applied to buried piping. At present ASME III Class 2 or 3 piping must meet the requirements of NC/ND 3600. These rules do not distinguish between above ground and underground piping. The Class 2/3 rules may be overly conservative when applied to underground pipe. If the decision is made to provide additional requirements for buried piping, GE will evaluate the most recent actions by piping code committees and determined if code approaches need to be supplemented when applied to ABWR. Examples of Code actions are:

(1) Proposed B31.1 Non-manuatory Appendix VII, Recommended Procedures for the Design of Restrained Underground Piping. (2)

(2) ASME III - DRAFT - General Requirements for ASME Section III Class 2 & 3 Underground Piping.

(3) ASCE Publication - Seismic Response of Buried Pipes and Structural Components - Report by the Seismic Analysis Committee of the ASCE Nuclear Structures and Materials Committee.

2. GE will has not yet determined if the SSAR should be revised to provide more definition of analysis methods to be used for evaluating the effects of external events such as wind, tornados, and missiles. At present, the rules for ASME III Class 2 or 3 piping apply for loads from external events the same as they do for seismic and other dynamic and static loads. If GE determines additional information in the SAR is needed to define magnitude of loads from external events or define Service Limit stress values for these events, the SAR will be revised.

STAFF EVALUATION

1. If GE plans to deviate from NC/ND 3600 rules, the alternate requirements should be provided for review
2. GE should describe how load magnitudes will be determined and/or service limit stress values for these events.

ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
March 23-27, 1992

Item No.: 427 By: _____

DESCRIPTION OF CONCERN:

Hydrodynamic building filtered loads are based on the Japanese K6/K7 plant design and soil conditions provide justification for applicability of those loads to the ABWR considering the variation in soil properties and their effects on the building response.

RESPONSE BY GE:

Based on past BWR plant experience, the trend indicates that the floor response spectra (FRS) increases as the foundation soil becomes softer. Since K6/K7 is a soft soil site, the resulting FRS for hydrodynamic loads are considered applicable for other site conditions and can be used for the standardized design.

STAFF EVALUATION:

Response appears acceptable but we should get NRC structural audit group concurrence.

CONCLUSION:

Closed: to be confirmed by NRC structural group

ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSIS
March 23-27, 1992

Item No.: A2B

By: _____

DESCRIPTION OF CONCERN:

a) Provide additional information to justify the feedwater thermal stratification load definition. Identify test programs and plant measurements which support the model.
b) Justify the application of a linear temperature profile (versus a hot to cold step change) on the pipe cross-section.
c) Thermal striping is not considered in the analysis. Provide evidence to support neglecting the thermal striping phenomenon in the fatigue analysis.

RESPONSE BY GE:

a) Test programs and plant measurements were obtained at the following plants: Leibstadt, Hanford Unit 2 and Nine Mile Point Unit 2. Additionally, an extensive finite element analysis of the Shoreham feedwater piping system was performed to obtain a better understanding of thermal stratification. See also the Response to Item No. A17.

b) Using a hot to cold step change at the center of the pipe will be overly conservative. The reasons are given below:

1. The analysis assumes the same thermal stratification for the entire length of horizontal pipe, but thermal mixing occurs along the pipe due to flow which would reduce the stratification.
2. A step change at the center creates the maximum bending moment. In the actual flow, the hot and cold fluid does not have a step change due to axial flow.
3. The probability for the change from hot to cold fluid occurring at the center of the pipe is small since the amount of flow required for stratification is less than 3% flow. If the dividing line is not at the center, then the bending moment due to stratification is reduced.

c) Temperature stratification between the top and bottom of the feedwater piping and nozzles has caused pipe bowing with pipe support damage and flange leakage, but no pipe failures. The temperature stratifications which have been measured have shown that stratification occurs for only short time durations following reactor scram as the hot piping is filled with cold water, and again during startups as feedwater heating begins, filling the cold piping with hot water. So far, operation of BWR feedwater piping systems have avoided fatigue failure due to prolonged operation with a fluctuating cold water-hot water interface, due to the fact that feedwater velocities are high enough to maintain the piping at constant temperature throughout during most of its operating time.

STAFF EVALUATION:

GE should provide the test and analysis requirements supporting their load definition for review

CONCLUSION:

a) + b) Closed / Confirmatory: GE to commit to an in-plant thermal stratification monitoring program in SSAR to verify adequacy of temperature protection.

c) Open: GE will provide a calculation to address thermal striping fatigue effects

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: B1 (29) By: S.J. Lin

DESCRIPTION OF CONCERN:

Currently a criteria document for the determination of break locations and dynamic effects associated with the postulated rupture of piping for the ABWR does not exist. GE should create such a document.

RESPONSE BY GE:

GE will incorporate the current SRP 3.6.2 criteria and postulated locations in the SAR. A separate criteria document is not required for determination of break locations.

STAFF EVALUATION:

GE committed to incorporate SRP 3.6.2 criteria and postulated (break) locations in the SAR but stated that a separate criteria document was not required for determination of break location.

During the March 23-27, 1992 ABWR piping design criteria and sample analysis audit at GE, the staff requested GE to have a criteria document for postulation of break locations. The staff also requested GE to provide documentation of procedures to be utilized during the ABWR design process for locating postulated break locations. The requested criteria and procedure documentation are ITAAC related issues and are separate from the break location criteria in the SAR.

CONCLUSION:

GE should provide the requested criteria and procedure documentation in order for the staff to complete its ITAAC review. The criteria and procedure should be available for staff review during the upcoming July 28 - Aug 1, 1992 followup audit.

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: B2 (3.) By: S.J. Lin

DESCRIPTION OF CONCERN:

The sample analysis of the effects of high energy line breaks in the main steam line was not complete at the time of the audit. Complete the analysis for NRC review. The analysis should be in accordance with revised Section 3.6.2.2 of the SAR.

RESPONSE BY GE:

Sample analyses of main steam line A with two typical break locations have been studied. The first break location is at the safe end nozzle and the second break location is at the sweepolet inlet to SRV A. Both breaks have been restrained by pipe whip restraints and by a pipe stopper (bumper). Assessment of the penetration loads will be submitted in the final report. It is evaluated based on the current SRP 3.6.2 criteria.

STAFF EVALUATION:

The acceptability of this information will be evaluated during the upcoming July 28 - Aug 1 1992 audit.

CONCLUSION:

The acceptability of the penetration loads analysis is on hold pending the results of the July 28 - Aug 1, 1992 audit.

NRC Audit of GE on
ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES
March 23-27, 1992

Item No.: B3 (31) By: S.J. Lin

DESCRIPTION OF CONCERN:

The procedures and criteria specified in Section 3.6.2.2 of the SAR relating to analytic methods to define blowdown forcing functions and response models for postulated ruptures of piping are inconsistent with procedures and criteria to be used for the ABWR plant as described during the audit. Revise Section 3.6.2.2 of the SAR to be consistent with current SRP 3.6.2 requirements and current GE procedure and criteria.

RESPONSE BY GE:

Blowdown forcing functions are determined by the method specified in Appendix B of ANSI/ANS-58.2-1988.

In addition, the forcing functions due to the postulated pipe breaks near the reactor or the branch connection is calculated by the solution of one-dimensional, compressible unsteady steam flow in the gas system. The numerical analysis is performed by the method of characteristics. The flow starts with steady flow from RPV to turbine. A pipe break boundary condition is applied at the break location for the pipe to reverse its flow direction. The pipe segment force time histories are calculated by the momentum change in the pipe segments of a close system. The broken pipe segment force time history is calculated by ANSI/ANS-58.2-1988.

The pipe displacement due to blowdown reaction load is modeled and analyzed using the commercially available computer program ANSYS. The stresses at the penetration and at other locations will be analyzed using nonlinear options. The required pipe whip restraint capacity is determined by the PDA program and used for selection of GE U-rod designs.

(31)

Item No.: B3 (Continued)

STAFF EVALUATION:

The staff requested GE to revise information relating to analytic methods to define blowdown forcing functions and response models for postulated ruptures of piping in Section 3.6.2.2 of the SAR to be consistent with information obtained during the March 23-27, 1992 ABWR, piping design criteria and sample analysis audit.

GE has provided additional information in their response to concern B2. The acceptability of this information will be evaluated during the upcoming July 28 - Aug 1, 1992 audit.

CONCLUSION:

The acceptability of the blowdown forcing function and response models provided in Section 3.6.2.2 of the SAR is on hold pending the results of the July 28 - Aug 1, 1992 audit.

ATTACHMENT 4

PRELIMINARY GE/ANL INTERIM PROCEDURE TO ACCOUNT FOR
ENVIRONMENTAL EFFECTS IN ABWR PIPING FATIGUE EVALUATION

PROPOSED INTERIM PROCEDURE TO ACCOUNT FOR ENVIRONMENTAL EFFECTS IN ABWR PIPING FATIGUE EVALUATION

(Prepared by W. Shack, ANL)

The current GE procedure to design against fatigue in carbon steel is a reasonable attempt to adapt the conventional fatigue analysis in Section III to account for environmental factors.

However, it was based on the limited data available in the early 80's, and the specific values for the threshold value of the temperature and the degree of reduction in life. As such, it underestimates the reduction in fatigue life experienced by carbon steels.

I discussed our analysis of the available data and the associated proposed fatigue design curves. Sam has proposed that an acceptable design procedure for the ABWR could be based on the following positions:

1. A conventional ASME Section III analysis be performed according to the edition of the code chosen for the licensing basis.

2. Supplementary fatigue analyses to account for environmental effects be performed using the ANL developed fatigue design curves (or modifications there of which better account for environmental effects).

3. The environmental effects should exempt components such as elbows, tees, and valve bodies for which the stress indices given in NB-3600 already provide large safety margins. In effect, this would restrict the environmental analysis to butt welds and components such as safe-ends which require detailed analysis.

4. Additional fatigue design curves should be provided to account for transients with strain rate $\geq 1 \times 10^{-4}$/S. A procedure to account for temperature changes in a transient should be developed.

5. For components for which the environmentally enhanced usage factors exceed 1, an alternate design procedure based on fracture tolerance and a postulated crack be permitted. This is intended to recognize that there are uncertainties in the interim fatigue design curves.

Sam, of course, can only propose this. The ABWR project office would have to approve this change from their current position based on GE 408HA414.

My personal opinion subject to further reflection, is that this provides a reasonable interim basis for fatigue design in the ABWR.

It is somewhat inelegant to have the exception rule for components with stress indices, but it is probably true that these components have sufficient conservatism, and detailed finite-element analyses would probably confirm their adequacy, but at a high cost. The flaw tolerant alternate is also reasonable considering the uncertainties inherent in the initiation design.