Docket File

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

May 20, 1992

Docket No. 52-001

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

Dear Mr. Marriott:

SUBJECT: AUDIT SUMMARY - ADVANCED BOILING WATER REACTOR (ABWR) PIPING DESIGN AND INSPECTIONS, TESTS, ANALYSES, AND ACCEPTANCE CRITERIA (ITAAC)

The Nuclear Regulatory Commission (NRC) Structural and Geosciences Branch staff and NRC consultants conducted an audit at General Electric Company's (GE's) office in San Jose, California, on March 23-26, 1992. The purpose of this audit was to review the GE proposed piping design criteria and sample analyses for the ABWR. In addition, the audit team also discussed with GE the proposed piping design ITAAC during the audit.

As a result of this audit, the staff found that GE performed adequate analyses of three selected piping systems. GE personnel were knowledgeable, experienced, and cooperative. The staff determined that the piping design ITAAC recently prepared by GE was inadequate because it did not provide sufficient detailed design acceptance criteria needed by the staff to make its final safety determination. GE agreed to revise the piping design ITAAC.

The staff raised a number of concerns and questions during the audit. The primary concerns included (1) the use of high, bounding seismic response spectra, (2) the lack of criteria for alternate analyses and design methods other than methods using response spectra and time history, (3) the lack of criteria and procedures for the analysis and design of piping and supports applicable to the entire ABWR. The staff requested that GE provide a written response expeditiuosly to address all the staff's concerns and questions identified in the audit report. The audit trip report is enclosed.

FOB 1/1

Should you have any questions concerning this report, please contact Mr. Son Ninh at (301) 504-1125 or Dr. Shou-Nien Hou at (301-504-2793) of this office.

The reporting and/or recordkeeping requirements contained in this letter affect fewer than ten respondents; therefore, OMB clearance is not required under P.L. 96-511.

Sincerely,

Original signed by Robert C. Pierson

Robert C. Pierson, Director
Standardization Project Directorate
Associate Directorate for Advanced Reactors
Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc w/enclosure:
See next page

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Mr. Patrick W. Marriott Docket No. 52-001

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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: March 23-26, 1992

NRC PARTICIPANTS: D. Terao (NRC), S. Hou (NRC), P. Bezler (BNL), G. DeGrassi (BNL), J. Braverman (BNL), and others (see Attachment 1)

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

I. SCOPE AND PURPOSE

The purpose of this audit was to review the adequacy of the General Electric (GE) proposed piping design criteria and sample analyses for the Advanced Boiling Water Reactor (ABWR). The staff is performing this review as part of the 10CFR Part 52 design certification process for the ABWR.

In reviewing the ABWR piping design, the staff had identified a number of areas for which GE did not provide design and engineering information at a level of detail customarily reviewed by the staff in reaching a final safety determination. The primary reason is that GE does not have as-built or as-procured information to complete pipe stress and support analyses for the final design. For this reason, the staff requested using design acceptance criteria (DAC) together with detailed sample analyses for reviewing and approving the ABWR piping and support designs. This approach enables the staff to make a final safety determination, subject only to satisfactory implementation and verification during the combined license (COL) review through appropriate inspections, tests, analyses, and acceptance criteria (ITAAC).

During the audit the staff asked GE to provide the piping design procedures and reviewed sample calculations of three piping systems which demonstrate the implementation of the procedures. GE provided a design criteria and analysis methods document (Reference 1) and three sample pipe stress reports (References 2, 3, 4) for staff review. During the audit, the staff and its consultants from BNL concentrated on reviewing the design procedures, acceptance criteria and the sample calculations. This included identification of additional documents needed to complete the review. In addition, information needed to perform confirmatory analyses of the sample piping systems by BNL was requested.

II. SUMMARY OF EFFORTS

The audit agenda, which is included as Attachment 2, covers the main areas of discussion and review. The audit began on Monday morning with introductory comments by NRC staff members, D. Terao, and S. Hou. They stated that the goals of this audit were to agree on Design Acceptance Criteria (DAC) for ABWR piping systems and to review the implementation of the criteria through audit of sample calculations. The piping design ITAAC recently prepared by GE (Reference 5) was inadequate because it did not provide the sufficiently detailed design acceptance criteria needed by the staff to make a final safety determination. The staff needs DAC which include key parameters, that are measurable and can be verified, to demonstrate that the as-built piping systems conform to the certified design. The DAC should cover the piping in the entire plant, not just the three sample piping systems. The DAC will become the governing criteria for all piping systems.

The audit proceeded with GE presenting and explaining their design criteria document. The audit team raised questions and discussed the issues as they came up. Audit concern forms were used to document and track specific questions and concerns that were raised and discussed. A total of 38 audit concern sheets were prepared and are included in Attachment 3. Some of the items were discussed and verbally resolved. GE will prepare written responses for final evaluation at a later date. The audit team spent approximately two days reviewing the GE analysis methods and criteria document and two days reviewing the sample calculations. GE provided the design record files (DRF) for each sample problem. Each DRF was a complete engineering record of the analysis and included all computer input and output and additional backup information and calculations. GE engineers were available to discuss and respond to technical questions from the reviewers. The audit concern forms were used to document and track specific items of concern.

At the conclusion of the audit, D. Terao gave an exit briefing to GE and NRC management discussing the overall findings and highlighting the significant open issues. A summary of the briefing is given at the end of this report.

III. QUESTIONS AND CONCERNS

The following is a summary of the questions and concerns raised by the audit team and documented in the audit concern sheets in Attachment 3. A summary of discussions and GE commitments is included where applicable.

1. Criteria and Procedures (See Items A1, A2, A6, A9, A26 of Attachment 3)

The criteria and analysis methods document provided by GE (Reference 1) did not provide an adequate basis for development of design acceptance criteria (DAC). The criteria covered only the three sample piping systems which included a main steam line, a feedwater line, and a safety relief discharge line. The staff wanted a piping and pipe support design criteria document which would cover the entire plant, including NSSS and BOP systems, and would be applicable to large bore and small bore piping. The staff also

wanted a more detailed document than was provided by GE.

Upon further discussion, it became clear that GE has more detailed design procedure documents which are available to their NSS piping analysts. While GE did not have specific procedures for ABWR piping, procedures which had been used in other projects were made available for review. GE also had a general piping design procedures manual ("green book") which provided detailed pipe stress analysis procedures. However, since this was an internal document, GE was reluctant to release it to the audit team for further review.

Since a detailed review of all piping procedures could not be completed within the audit time frame, the audit team requested copies of the relevant documents for further review. A list of additional information needed by NRC and BNL was prepared (Table 1). GE agreed to provide all documents except for the procedures manual ("green book"), the design record files, and proprietary portions of computer manuals. GE would make these documents available for audit but would not release them to NRC. Since these are the most critical design documents, this issue must be resolved in order to complete the staff review on schedule.

There are a number of areas in which the procedures were clearly deficient. GE had no procedures on pipe support analysis and design. There were no procedures on small bore piping qualified by simplified methods. There were also no procedures for buried piping or piping exposed to external events (wind, tornado, missile loads, etc.). These areas will remain unresolved unless GE develops new procedures.

2. Seismic Analysis Loads and Methods (See Items A7, A8, A12, A13, A14, A23, A24, A25 of Attachment 3)

A number of questions were raised regarding seismic analysis loads and methods. Seismic loads were significantly higher in the standard ABWR than in the Japanese ABWR even though the Japanese maximum ground acceleration was 50% higher. This could result in relatively stiff piping systems with large numbers of snubbers. The audit team reviewed sample design response spectra and noted spectral peaks as high as 10-15 g's with 2% damping. Some spectra had very broad multiple peaks. In addition, significant amplifications from the ground level to higher building elevations were seen. GE attributed the difference between the standard ABWR and the Japanese ABWR to the soil-structure interaction analysis. The standard ABWR analysis enveloped a range of 14 soil conditions. The Japanese ABWR analysis was performed for the site specific soil condition which was softer than the softest standard plant site. The softer soil essentially reduced the amplification of earthquake motion through the building in the frequency range critical to piping response. GE also pointed out a conservatism in the generation of SSE spectra. The analysis was performed for the OBE and the OBE spectra were doubled to generate the SSE spectra. Thus, the SSE spectra generation did not take advantage of the higher damping at SSE levels. The staff expressed concerns over the implications of using overly conservative response spectra to design the piping systems. This issue will be followed up during the upcoming structural audit.

Another seismic load concern that was discussed was the effect of amplification of spectra due to local flexibilities (such as floor flexibility or piping attached to steel platforms or other building steel structures). In the sample calculations, GE had applied a 1.2 amplification factor to hydrodynamic loads for piping connected to a steel structure. GE was asked to provide justification for the factor and procedures on how such factors should be applied.

GE was also asked to provide justification for SRSS of inertia and relative anchor displacement effects, the basis for application of seismic displacements, and criteria for order of combination for inertia, displacement and loading events. GE was also asked to address possible additional decoupling criteria for branch lines due to stiffness effects of branch lines to the main line if supports are nearby.

3. Damping (See Items A9, A11, A19 of Attachment 3)

The GE criteria document included a table of damping values for piping and pipe support components. GE was asked to provide the basis for damping values for snubbers and struts and explain how different component damp values are included in a modal analysis. GE explained that the snubber and strut values were based on Regulatory Guide 1.61 values for bolted structures. They agreed to change the table to clarify this. With regard to using different component damping values, GE explained that they have a method for determining modal damping for composite structures. They indicated that this method was not used in the sample problem but agreed to provide additional information on it.

In reviewing the sample problems, it was noted that some systems had both small (<12 inch) and large (>12 inch) diameter piping. Reg. Guide 1.61 specifies different damping values for these pipe sizes. GE was asked to provide a procedure explaining how damping is determined for piping systems which contain both large and small diameter piping.

4. Hydrodynamic Loads (See Items A10, A15, A20, A27 of Attachment 3)

Hydrodynamic loads due to SRV discharge and LOCA were based on the Japanese ABWR design. Since the building filtered loads are dependent on the building design and soil conditions, GE was asked to provide additional justification for applying these same loads to the standard ABWR which is intended to cover a wide range of soil conditions. GE was also asked if forcing function variations were considered in performing time history analysis of the piping. GE indicated that studies have shown piping systems to be relatively insensitive to those variations and agreed to provide additional information. GE was also asked to clarify the RV2 (SRV_{adv}) definition in their criteria document, ensure that it bounds all SRV loads and explain when and what factors may be applied to consider such events as single valve opening, ADS, etc.

With respect to SRV valve lift acoustic loads, the GE criteria document stated the load is calculated based on a 20 msec valve opening time. The audit team asked how GE ensures that this value is met since the specific

value used in the system is unknown at this time. GE felt that specifying this value is not necessary since it is considered a bounding value, but agreed to provide additional information. The same concern applies to the Turbine Stop Value closing time.

5. Component Classification and Mater. s (See Items A3, A4, A5 of Attachment 3)

A discrepancy was noted between the SSAR Table 3.2-1 for SRV piping ASME Code classification of Class 2/3 versus other SSAR sections which refer to it as Class 3. GE indicated that they would correct the SSAR to make it consistent. The audit team asked GE to provide the ASME Code classification of the SRV quenchers as well as the design and analysis method. GE agreed to rovide this information. The material designations for the three sample iping systems were specified as ASTM/ASME in the GE criteria document. This implies that it could be bought to either specification. GE was asked to provide clarification.

6. Thermal Analysis (See Items A17, A28 of Attachment 3)

GE was asked if fatigue evaluations will be performed for piping systems subjected to hot and cold thermal mixing and to identify such systems. Section 3.9.7.2 of the SSAR makes a general statement about including these effects but provides no details. The criteria document states that thermal stratification loads in the feedwater line will be analyzed and included in the fatigue evaluation. The thermal stratification methodology was discussed with the GE cognizant engineers. The piping analysis method appeared acceptable except for the load application. The stratification model assumed that the pipe was hot on top and cold on bottom with a step change in temperature at the centerline. The piping analysis input was based on a linear top to bottom temperature profile which is less conservative. In addition, GE did not consider potential high cycle fatigue effects due to thermal striping. GE was asked to provide additional justification for their methodology and additional test information to support their thermal stratification load definition.

7. Fatigue (See Item A18 of Attachment 3)

Recent Japanese tests have suggested that the ASME Code fatigue curves may be unconservative for materials subjected to BWR environmental conditions. GE was asked to explain how this is being considered in their analysis. GE engineers explained that these effects have been looked at. They presented the results of their test program to study environmental effects on fatigue life. In the GE program, notched pipe samples were subjected to mean stresses and load controlled heatup/cooldown stress cycles of up to 1.35 S_y. The tests were performed at 450°F and 550°F. Environmental conditions included tests in air, in 0.2 ppm oxygenated water, and in 8 ppm oxygenated water. The results of these tests indicated that some data points fell below the ASME Code design fatigue curve. The most significant deviations were at the low cycle end (<1000 cycles). However, GE pointed out that the test program was conservative and went beyond conditions that the actual components undergo. The strongest environment effect was seen in the 8 ppm oxygenated water

environment. It was less severe at 0.2 ppm which is more representative of the BWR environment. Mean stresses also had a strong effect but may have been too high compared to Code assumptions. Temperature and notch strain were also more severe than the BWR environment.

GE used the test results to develop a tentative position document which is currently used in Japanese K-6 and K-7 plants. The rules exempt additional fatigue evaluation on environmental effects when certain conditions are met, such as when fluid temperature is below 245°C, oxygen content is below 0.3 ppm, and tensile stress hold time does not exceed ten seconds. The exemption rules also extended to elbows, tees, and valve bodies when these components are conservatively designed and analyzed per stress index method. Thus, only the circumferential girth butt welds are considered critical and should be evaluated. The rule for girth butt welds is to modify the local peak stress through four factors, namely the notch factor, the mean stress factor, the environmental correction factor, and the butt weld strength reduction factor. The audit team asked GE to provide additional documentation to support their position.

8. Load Combinations (See Items A20, A21 of Attachment 3)

The GE criteria document included a number of tables of load combinations for piping, supports, and components. Various SRV and LOCA hydrodynamic load events were included. The combinations appeared reasonable and GE stated that they were consistent with load combinations used in earlier BWR plants. The audit team asked GE to provide the BWR6 load combinations for comparison.

The audit team noted a few apparent discrepancies in the load combinations. The functionality/operability requirements of S.R.P. 3.9.3 were not included. GE stated that these requirements are included in a footnote to the SSAR load combinations table and agreed to revise the criteria document to reflect this. The audit team also pointed out that the thermal expansion stress limits per ASME Code equations 10 and 11 were not included in the criteria document. There were a number of other minor discrepancies identified in the load combination tables. GE agreed to make additional revisions and submit them for further review.

9. Plastic Analysis (See Item A22 of Attachment 3)

The audit team wanted to assure that the criteria document covers all analysis methods that will be used in the ABWR piping design. GE was asked if it plans to use plastic analysis methods in accordance with ASME Code section NB-3200. Since the Code does not provide specific requirements in this area, the audit team emphasized the importance of providing the GE methodology and acceptance criteria for qualifying a piping system by plastic analysis methods. As an alternative, it will be assumed that these methods will not be used.

10. Flooded Load (See Item A16 of Attachment 3)

The GE criteria document specified that the main steam line would be

designed such that it may be flooded with cold water. This load would be included in the weight analysis and in the fatigue analysis. However, the load combination tables in the criteria document and the stress report did not include this load. GE was asked to determine whether this load was actually considered. If it was used in the fatigue analysis, how many cycles were considered?

11. Pipe rupture locations and associated dynamic effects (See Items B1 to B3 of Attachment 3)

During the audit it was found that GE had not established a structured program for the control and uniform implementation of criteria and procedures for the determination of rupture locations and dynamic effects associated with the postulated rupture of piping in the ABWR plant. Such information should be made available to the staff for review when completed.

In addition, at the time of the audit, the sample analysis of the rupture locations and dynamic effects of the postulated ruptures in the Main Steam line was incomplete and hence not available for audit. Instead, a description of the analysis being performed was provided. The methods of analysis described during the audit was not in accordance with the method described in Sections 3.6.2.2 and 3.6.2.3 of the ABWR SSAR. GE personnel explained that the procedures and criteria relating to analytical methods to define blowdown forcing functions and response models for postulated ruptures of piping as described in these sections of the SSAR were outdated and inconsistent with procedures and criteria to be used for the ABWR plant. Moreover, the criteria specified in these Sections of the SSAR were found to be not in total agreement with requirements in current SRP 3.6.2, Rev. 2, June 1987.

12. Leak-before-break (LBB) evaluation (See Items B4 to B10 of Attachment 3)

GDC 4 allows approval of LBB application on a plant specific and piping system specific basis only and hence not applicable to the standardized ABWR plant design. However, COL applicants who reference the ABWR certified design will be permitted to apply LBB by submitting an LBB analysis for staff approval. Guidelines for COL applicants who elect to apply for approval of LBB analyses for selected piping are provided in Section 3.6.3 and Appendix 3E of the ABWR SSAR. This section and appendix were reviewed during the audit. The review was performed on the basis of SRP 3.6.3 and NUREG-1061, Vol. 3.

We found that Section 3.6.3 of the ABWR SSAR provides an acceptable approach for LBB application and acceptable procedure for LBB evaluation. The systems identified were found to be acceptable candidate system provided they are subject to the limitations specified in Section 3.6.3.2 of the SSAR. In addition, our audit found the following:

1. In Section 3E.2 of Appendix 3E to the SSAR, procedures and criteria for bimetallic welds were not included and should be provided.

2. In Section 3E.2.1, Justification for the modified tearing modulus

method will be required.

3. In Section 3E.2.2, material specification include both seamless and welded pipe which was contrary to information obtained during the audit that only seamless pipe was to be used in safety related piping systems. Clarification of these specifications will be required. In addition, the description of the fracture toughness characterization test program should be modified to be consistent with this clarification and the tearing modulus defined in Section 3E.2.1. Moreover, GE should indicate that the extent of the test program indicated in Table 3E.2-4 may not be representative of the actual test program required for approval of a COL application for LBB qualification of selected piping systems.

   In Section 3E.2.3, toughness properties derived from the open literature may not be appropriate for specific LBB submittals but should be in accordance with Sections E.1.2 and SRP 3.6.3. Also, the J_{mod} - T_{mod} plot in Figure 3E.2-8 for carbon steel contains data attributed to Gudas (Reference 14 to Section 3E.2). Clarification of these data should be provided.

   Section 3E.3.1 describes the (J/T) methodology and includes a proposed linear "interaction formula" for critical flaw length when the applied stress field is a combination of tension and bending. Justification of the proposed formula will be required.

   Section 3E.3.2 describes the application of the (J/T) methodology to carbon steel. Values for the Ramberg-Osgood parameters for the characterization of carbon steel provided in Section 3E.3.2.2 should be regarded as for illustrative purposes only and will need to be developed for each COL LBB application.

   Section 3E.3.2 provides that for stainless steel the modified limit load methodology of SRP 3.6.3 may be used in lieu of the (J/T) methodology.

4. In Section 3E.4.2, the leak rate calculation method for carrying saturated steam is based on a theoretical model developed by Moody. This method has not been verified by test. Accordingly, the method is in need of verification for COL LBB applications.

   Section 3E.5 provides a general discussion of leak detection capabilities. Recognizing, that advances may occur in this area prior to COL LBB applications, detection capability reviews were not performed. In general, based on current SRP 3.6.3 requirement, commitments that leak detection systems equivalent to RG1.45 and a margin of 10 on the leakage prediction, will be required.

5. Section 3E.6 provides guidelines for the preparation of LBB reports. Examples for the Main Steam line and Feedwater line were included. Staff reviews of these lines as examples should not be interpreted that approval of the application of LBB procedures to these lines

has been granted. The reviews were performed for methodology only.

The Main Steam and Feedwater examples are contained in Sections 3E.6.1 and 3E.6.2, respectively. We found that the evaluations of the susceptibility of the systems to water hammer and thermal fatigue should be expanded to include considerations of other direct and indirect sources of potential piping ruptures.

The material specifications include SA 155 KCF70 for the Main Steam and SA 333, Gr. 6 for the Feedwater lines. These specifications are not consistent with those specified in Section 3E.2 and should be clarified.

IV. MAJOR FINDINGS AND OPEN ITEMS

The following is a summary of major findings and open items identified in this audit:

1. The criteria and analysis methods document provided by GE (Reference 1) was limited in scope and did not provide a sufficient level of detail. The criteria was only applicable to the three sample piping systems which are all in the scope of nuclear steam supply systems (NSSS). GE seemed to lack procedures covering the normal balance of plant (BOP) scope of piping. This includes such areas as pipe support design, simplified methods for small bore piping, analysis and acceptance criteria for buried piping, etc.

2. GE did not provide detailed procedures that can be used for all ABWR piping design and for development of DAC. The GE internal procedures manual (green book) includes the necessary level of detail for pipe stress analysis. However, GE was reluctant to release this manual to the audit team for further review. If this document is not made available, there will be an adverse impact on the schedule for completion of staff review.

3. In reviewing the three sample problems, no significant technical problems were identified (aside from those listed in the audit concern forms). However, the audit team identified additional information needed to complete the reviews and perform the confirmatory analysis. This information was included in the design record files (DRF) for the sample problems. Each DRF was a complete engineering record of the analysis and included backup calculations and computer runs. GE was reluctant to release the complete files but agreed to send selected information needed by the audit team to the staff after the audit. Delays in receiving this information will also adversely affect the schedule of staff review.

4. There were several questions raised regarding seismic analysis loads and methods. The staff was particularly concerned that the seismic response spectra used to design the piping appeared extremely conservative. This generally results in stiff piping systems with

large numbers of snubbers. The staff was concerned that conservative spectra would lead to overly constrained piping systems or force the future licensees to request additional relief from the Code stress limits. The response spectra issue will be further pursued during the NRC structural audit.

5. With regard to pipe rupture criteria, Sections 3.6.2.2 and 3.6.2.3 of the SSAR should be revised to be in accordance with current SRP 3.6.2, Rev. 2 requirements and the procedures and criteria to be utilized for the ABWR plant. In addition, the sample analysis of the rupture locations and dynamic effects of the postulated ruptures in the Main Steam line should be made available to the staff for review when completed.

6. For LBB applications, it should be considered as a design option for COL. The staff identified several open issues pertaining to the detailed criteria used in the sample calculations. These issues are described in II.12 above and should be resolved.

7. A total of 38 concerns/questions were documented by the audit team on the audit sheets included in Attachment 3. Although some of the items were verbally resolved, GE must prepare and submit written responses for final evaluation.

V. EXIT MEETING

An exit meeting was held on Thursday afternoon. It was attended by management of GE and NRC. D. Terao described the purpose, scope, and major findings of this audit. He stated that the audit was going well and that GE piping personnel were very knowledgeable, experienced, and cooperative. However, there were a number of concerns raised by the audit team. The primary concerns include 1) the definition of potentially restrictive seismic response spectra, 2) the lack of criteria for alternate analysis and design methods (other than response spectra and time history analysis), and 3) the lack of criteria and procedures for the analysis and design of pipe supports. In addition, the inability to obtain copies of selected GE documents might hamper the completion of the review effort and issuance of the SER.

References

1. GE draft report NEDC-xxxxx, Rev. 0, "ABWR SSAR Main Steam, Feedwater and SRVDC Piping Systems Design Criteria and Analysis Methods," February, 1992.

2. GE draft report NEDC-xxxxx, DRF No. A00-05137, Rev. 0, "Advanced Boiling Water Reactor, Feedwater Loop A Piping and Equipment Loads, "February, 1992. GE draft report NEDC-xxxx, Rev. 0, "ABWR SSAR Main Steam Line A and SRVDC piping Stress Analysis."

4. GE draft report NEDC-xxxxx, DRF No. A00-05137, Rev. 0, "Advanced Boiling Water Reactor SRVDL Wetwell Piping Stress Analysis Design Report,"

March, 1992.

5. GE letter to NRC, P.W. Marriott to R.C. Pierson, "Piping Design Inspections, Tests, Analyses and Acceptance Criteria (ITAAC)," MFN No. 063-92, Docket No. STN 50-60[illegible], EEN-9237, March 11, 1992.

TABLE 1

Additional Information Needed by NRC/BNL

1.* Design Record File - for Main Steam, Feedwater, and SRV Wetwell. (Selected information identified by audit team).

2. Reference documents. in GE Criteria Document Section 6.0 - need d, e, f, g, (front end and applicable spectra), h to n.

3. Reference Documents in #1 above not included n #2 above (for 3 sample lines).

4. Reference Documents listed in Stress Analysis Design Report not included above (for 3 lines).

5. GE methods and criteria document no. 386HA579.

6.* Computer Manuals - PISYS, ANS17, EZPYP, RVFORCE, TSFORCE.

7. SSAR - Section 3.7, 3.9 (text, figures and tables), 3.8 (only figures).

8. Analysis Procedures - Piping Design Subsection Procedures Manual (listed on 2 sheets).

9.* Floppy disk of model input data and all loading in SAP format for 3 lines.

10. Design Procedure - Balance of Plant and Containment Ringing - Report No. 23A1351.

11. Duty Cycles Report No. 23A1455.

12. Containment Load Report (1.D.7) APL A21-2040

13. ABWR-88027

14.* Microfiche of all computer output for three sample problems (included in design record file).

15. GE drawings 103E 1526 SRV W/W piping and SRV 103E 1481 SRV W/W piping. Computer model drawing, "Typical numbering sequence - SRV DL W/W.

16. Equivalent set of drawings as item 15 for Main Steam and Feedwater lines.

*High priority-needed ASAP

ATTACHMENT 1

AUDIT MEETING ATTENDEES

ATTENDEES

PIPING DESIGN AUDIT

MARCH 23-27, 1992

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ATTACHMENT 2

AUDIT AGENDA

NRC Audit of GE on

ABWR PIPING DESIGN CRITERIA AND SAMPLE ANALYSES

March 2[illegible]-27,1992

AGENDA

I. Review Design Criteria

A. Code classification of all seismic Category I piping and supports, and their jurisdiction boundaries

B. Design loads

(1) Operating transients
- Major pressure and thermal cycles
- Emergency transients
- Thermal stratifications and stripings
- Supression pool hydrodynamics

(2) Seismic

(3) Dynamic effects of postulated high-energy line breaks

(4) Guidance to distinct primary and secondary loads

(5) Load combinations

C. Analysis methods

(1) Thermal analysis
- For expansion under operating thermal cycles
- For local effects of thermal stratification

(2) Dynamic analysis
- For seismic
- For hydrodynamic events
  - responses to supression pool dynamics
  - responser to hammer type loads due to valve actuations

(3) Fatigue evluations

D. Acceptable Limits

(1) Allowables established by Code for piping and support design under various service levels

(2) Construction tolerences for as-built concilliation to address concerns of NRC Bulletin 79-14.

E. Other Considerations:

(1) Criteria to ensure protection of seismic category I piping and supports against possible failure of non-seismic components and structures.

(2) Criteria to ensure application of good engineering practices in pipe support design.

(3) Consideration for errosion/corrosion protection
- Allowing thicker pipe wall?
- Using better piping material?
- Using more stringent fatigue curves?
- Conducting specific ISI?
- or something else.

(4) Consideration for flooding of main steam.

II. Audit of sample calculations and documents for piping stress analysis

A. Stress analysis of the following piping systems:
- Main steam
- Feedwater
- SRV discharge line in wetwell

B. Sample pipe support calculation

C. Sample of design specifications for piping and pipe supports

D. Sample procurement procedures to show control of material and fabrication of piping and supports

III. Discuss additional information needed by NRC for conducting confirmatory analyses.

IV. Discuss approach to define methods, procedures and requirements for optional case-specific and plant-specific leak-before-break applications.

V. Audit of sample high-energy line break analysis for feedwater piping (blowdown loads, pipe whip restraint calculation, location of high stress).

ATTACHMENT 3

AUDIT CONCERN SHEETS

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

Item No.: A1 By: _____

DESCRIPTION OF CONCERN:
Request a list of procedures for analysis methods / criteria for piping and piping supports. Then, copies of selected procedures can be requested.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 2 By: _____

DESCRIPTION OF CONCERN:

Request 1) Response spectra for seismic and other loads
2) References in Criteria Doc.
3) SSAR 3.7, 3.9, & applicable figures (e.g. reactor Bldg. cross sections)
4) Model input data including floppy disk & load cycle/temp. duty for all 3 sample piping systems.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 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 ~~qualified~~ Class 3 elsewhere in the SSAR.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 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:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 5 By: _____

DESCRIPTION OF CONCERN:
W/by are both ASTM and ASME designation presented in Criteria Document ? - Inquiries could be brought to ASTM.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 6 By: _____

DESCRIPTION OF CONCERN:

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

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 7 By: _____

DESCRIPTION OF CONCERN:

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

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 8 By: _____

DESCRIPTION OF CONCERN:

8 Need ~~to~~ more piping decoupling/interaction criteria (e.g. SSAR 3.7.2.3.1 ~~and~~ use 1/3 pipe size, & stiffness of branch lines if supports are nearby).

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A9 By: _____

DESCRIPTION OF CONCERN:

Request criteria document(s) discussing dynamic analysis criteria in more detail (e.g. basis for highest freq. of interest, damping & Δt for time history analyses; I.S.M. method of analysis, modal analysis method, how is the "effective/weighted" modal damping determined and used, etc.)

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 10 By: _____

DESCRIPTION OF CONCERN:

~~Con't ± 10% peak broadening~~

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

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 11 By: _____

DESCRIPTION OF CONCERN:

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

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A12 By: _____

DESCRIPTION OF CONCERN:

1. Provide Basis for application of displacements (all positive values).
2. Provide justification for SRSS combination of inertia + disp. effects
3. " criteria for order of combination for inertia, disp. & loading events

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 13

By: _____

DESCRIPTION OF CONCERN:

1) Interaction concern: flexibility of building local structure affecting/amplifying (e.g. floor flexibility) floor response spectra - how addressed
2) Also piping amplifying spectra for broad line analysis - how addressed?
3) Provide justification for the 1.2 factor for hydrodynamic amplification factor to account for local flexibilities (if it will be used)

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A.14 By: _____

DESCRIPTION OF CONCERN:

1) Not clear — how many cycles will be used for seismic + other loads?
2) What is the basis for using 1/2 SSE (floor spectra) for OBE (floor spectra)? Not consistent with SSA at ground level this statement is O.K.
3) Cldg rocking effects added to vertical spectra?

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 15

By: _____

DESCRIPTION OF CONCERN: (to be purchased) will have a SRV valve rise time greater than

1) How do you insure 20 ms?
2) Same applies to Turbine Stop Valve.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A.16 By: _____

DESCRIPTION OF CONCERN:

Flooded load still used? How/why? No. of cycles?

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 17 By: _____

DESCRIPTION OF CONCERN:

1) Will GE consider/perform fatigue evaluation for thermal effects when piping involves hot & 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:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 18 By: _____

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

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 19 By: _____

DESCRIPTION OF CONCERN:
When a piping system includes both small (< 12 inch) and large diameter piping (as in mainsteam / SRV sample problem) how is the damping value determined? Provide procedures to determine damping for both ISM and USM method of analysis. Provide justification for methodology.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 20 By: _____

DESCRIPTION OF CONCERN:

1) Need to clarify RV2 ① definition (single valve, ADS, all etc.) and ② factors used (including reference document). Does SRV all valve bound all RV2 loads in GE criteria document

2) Functional/operability requirements per SRP 3.9.3 not in GE criteria document

3) ASME equations 10 & 11 not in criteria document

RESPONSE BY GE:

4) What revisions will be made to Tables in criteria document

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 2-1 By: _____

DESCRIPTION OF CONCERN:
Provide BWR 6 load combination definitions.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 22 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:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 23 By: _____

DESCRIPTION OF CONCERN:

Provide description & bases of spectra interpolation/extrapolation procedures (for different elevations/locations).

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 24 By: _____

DESCRIPTION OF CONCERN:

What is the method of seismic analysis for the main steam piping beyond isolation valve outside containment to Turbine Bldg. If dynamic analysis will be used, then what document provide the seismic spectra - input.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 25 By: _____

DESCRIPTION OF CONCERN:
Why does piping analysis use ZPA for high frequency effect rather than the acceleration at the highest frequency at which the modal analysis ends?

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A 26 By: _____

DESCRIPTION OF CONC:
1) What are the analysis/methodology and acceptance criteria for revised piping analysis (beyond short description in SSAR).
2) What provisions are provided for protection from external events (e.g. wind, tornado, missile). If no protection is provided for some of the events, what are the analysis/methodology and acceptance criteria

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A27 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 these loads to the ABWR considering the variations in soil properties and their effects on the building response.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: A28 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. ~~Provide evidence that~~ 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:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: B1 By: _____

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:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: B2 By: _____

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:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: B3 By: _____

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

RESPONSE BY GE: ABWR PLANT AS DESCRIBED DURING THE AUDIT. REVISE SECTION 3.6.2.2 OF THE SAR TO BE CONSISTENT WITH CURRENT SRP 3.6 REQUIREMENTS AND CURRENT GE PROCEDURES AND CRITERIA.

STAFF EVALUATION:

CONCLUSION:

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

Item No.: B4 By:_____

DESCRIPTION OF CONCERN:

IN SECTION 3E.2.1 OF THE SSAR, GE PROPOSED THE USE OF A MODIFIED J-INTEGRAL AND ASSOCIATED MODIFIED TEARING MODULUS FOR BEYOND J-CONTROLLED CRACK GROWTH CHARACTERIZATION. JUSTIFY THE PROPOSED J_{mod} - T_{mod} CHARACTERIZATION.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: B5 By: _____

DESCRIPTION OF CONCERN: FRACTURE TOUGHNESS

SECTION 3E.2.2.1 DESCRIBES THE CARBON STEEL TEST PROGRAM. GE SHOULD INDICATE THAT THE EXTENT OF T PROGRAM INDICATED IN TABLE 3E.2-4 MAY NOT BE REPRESENTATIVE FOR THE ACTUAL TEST PROGRAM REQUIR FOR APPROVAL OF AN APPLICATION OF LBB QUALIFICATI OF SELECTED PIPING SYSTEMS.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: P.6 By: _____

DESCRIPTION OF CONCERN:

SECTION 3.6.3 OF THE SSAR DOES NOT CONTAIN PROCEDURES AND CRITERIA FOR LBB EVALUATIONS OF BIMETALLIC WELDS. PROVIDE THESE PROCEDURES AND CRITERIA

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: B7 By: _____

DESCRIPTION OF CONCERN:

IN SECTION 3E.3.1.3 OF THE SSAR, GE PROPOSED A LINEAR INTERACTION CRITERION FOR TEARING INSTABILITY EVALUATIONS FOR COMBINATIONS OF APPLIED TENSION AND BENDING STRESSES. JUSTIFY THE PROPOSED CRITERION.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No : B8 By: _____

DESCRIPTION OF CONCERN:
IN SECTION 3.6.4 OF THE SSAR GE PROPOSED A PROCEDURE FOR ESTIMATION OF LEAK RATES DURING BLOWDOWN OF SATURATED STEAM. JUSTIFY THE PROPOSED PROCEDURE.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: B9 By: _____

DESCRIPTION OF CONCERN:

CLARIFY THE GUDAS DATA IN FIG. 3E.2-8 OF THE SSAR.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION:

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

Item No.: B1D

By: _____

DESCRIPTION OF CONCERN:
THE MATERIALS SPECIFIED IN SECTIONS 3E.2.2, 3E.6.1.3 AND 3E.6.2.4 FOR THE REACTOR COOLANT PRESSURE BOUNDARY PIPING ARE INCONSISTENT. CORRECT THE INCONSISTENCIES TO SPECIFY THE MATERIALS TO BE USED.

RESPONSE BY GE:

STAFF EVALUATION:

CONCLUSION: