Enclosure

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

May 6, 1992

MEMORANDUM FOR: Robert C. Pierson, Director
Standardization Project Directorate
Division of Advanced Reactors
and Special Projects
Office of Nuclear Reactor Regulation

THRU: Brian K. Grimes, Director
Division of Reactor Inspection
and Safeguards
Office of Nuclear Reactor Regulation

FROM: Eugene V. Imbro, Chief
Special Inspection Branch
Division of Reactor Inspection
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Office of Nuclear Reactor Regulation

SUBJECT: GE ABWR DESIGN PROCESS ASSESSMENT

At your request, a team was put together by DRIS/RSIB to assess the feasibility of performing an inspection of the US ABWR design process at GE, San Jose. The team visited the GE offices the week of March 30, 1992 with the purpose of ascertaining the status of supporting documentation for the SSAR, identifying the design products and performance elements that could be evaluated by NRC during future inspections and to verify whether a documented process existed to control the implementation of the certified design. To the extent that the documents specifying discipline interface and systems interface requirements existed, the team planned to verify whether they were complete and specific enough for a design organization to produce detail designs without compromising the integrity of the certified design.

The team selected two candidate systems for review to test the availability of design documentation supporting the SSAR and to determine whether the design documentation would support a future comprehensive inspection to validate the functional and numerical information in the SSAR and the post-design certification design control process.

The team selected the residual heat removal (RHR) and reactor building cooling water (RCW) systems as representative examples of systems that would typically be within the design scope of an NSSS vendor, as in the case of RHR, or an architect engineer, as in the RCW system.

A discussion of the GE design process for the US ABWR and the status of the design documentation is provided in Enclosure 1. A list of those who participated in the inspection is included in Enclosure 2.

The observations of the team based on the review of document samples and discussions with the GE staff are as follows:

Design information supporting the SSAR, except for "common engineering documents" that support the design of safety systems engineered by Hitachi and Toshiba for Japanese units K6/K7, is retained at the offices of Hitachi and Toshiba in Japan. GE stated that the contractual terms between GE and its partners allow GE access to the design record files in Japan for a period of 10 years from the date of contract. However, GE has not developed plans to obtain copies of the Japanese design documentation that exists at the time of design certification for record purposes in support of the US ABWR. GE feels that all the necessary information required for safety determination by the NRC has already been provided in the SSAR.

For systems not within the GE design scope for K6/K7, the supporting documents available at GE are the design record files (DRF) and the common engineering documents listed in the master parts list (MPL) as mentioned above. The common engineering documents are applicable to K6/K7 and GE has identified about 100 design action list (DAL) items as of March 1992, which are generic design issues that must be implemented to meet existing US safety, regulatory, performance or contractual requirements. GE does not plan to incorporate, prior to design certification, these DALs or others that will be identified in the future. The GE design record files contain the lead GE engineers' notes, calculations and engineering judgement that form the basis for GE acceptance of the common engineering documents. No formal review of most of the contents of the design record files have been performed. No formal approved calculations were available for the selected systems. In addition, major design issues identified in the DALs, such as conversion to US codes and standards, ultimate heat sink temperature, and changes to electrical and I&C systems will not be incorporated in the US ABWR until first-of-a-kind engineering (FOAKE). This is after final design approval issuance.

It appeared that the K6/K7 design data developed through Hitachi and Toshiba calculations do not include margins for engineering judgement, equipment wear, tolerances, assumptions, etc. In Japan, margins are added in the procurement specifications. Therefore, the numerical values in the SSAR may not contain margins as would have been expected for a US designed plant. During the FOAKE, efforts would have to be expended in making the US ABWR data contained in the SSAR and design certification rule consistent with US practice where margins are added in the design phase (in determining component ratings or instrument setpoints) rather than at procurement.

In response to the team's question regarding the control of the US ABWR design after certification, GE stated that they had not yet developed procedures for controlling changes to the certified design.

The documentation currently available at GE for the RHR and RCW systems is not adequate for an inspection of supporting design documents to validate the information in the SSAR. Since many of the supporting documents are for the Japanese K6/K7 design and the DALs have not been incorporated, it is

inappropriate to conduct an inspection until after GE has completed substantial portions of its US ABWR design documentation during FOAKE.

We conclude that GE should develop a controlled process to assure that the conditions of the design certification are not inadvertently compromised during FOAKE. We also recommend that inspection(s) be scheduled after an appropriate control process has been developed and substantial progress made by GE on completing the US ABWR design to allow the staff to independently verify the adequacy of the procedures and implementation of those procedures in completion of the US ABWR design.

Eugene V. Imbro, Chief
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Enclosures:
1. GE ABWR Design Process Assessment
2. Design Process Assessment Team

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GE ABWR DESIGN PROCESS ASSESSMENT

1.0 DESIGN PROCESS

System engineering for the Japanese K6/K7 units is a cooperative effort between GE, Hitachi and Toshiba. GE has the lead for the reactor vessel and internals, the recirculation system, the control rod system, and the nuclear boiler system. The "common engineering documents" for K6/K7 (generally upper level documents) are reviewed and signed off by all the three parties. About 700 out of the total of 740 such documents have been issued. The common engineering documents are reissued with a new cover sheet for US ABWR and are included in the master parts list (MPL). An internal GE review process identifies changes required for the common engineering documents to meet US code/regulatory requirements, and such changes are listed in the design action list (DAL). GE does not plan to incorporate the DALs before design certification, but plans to do so during the first-of-a-kind engineering activity.

The design of GE systems is performed in accordance with the GE QA program. Hitachi and Toshiba have design QA programs meeting the requirements of 10 CFR 50, Appendix B. GE performs periodic programmatic QA audits of the design process at Hitachi and Toshiba, but does not perform technical audits of the detailed engineering design products.

The team did not find a generic procedure for calculations at GE that specified format, review, verification of assumptions, approval, etc. Procedures for specific types of calculations detailing the methodology to be used, description of computer inputs, etc. were available.

The team's review of samples of engineering review memoranda (ERM) utilized by GE to review K6/K7 design documentation showed that the assignment of discipline interface reviews was at the discretion of the ERM originator. There were no mandatory or suggested minimum discipline interface reviews for each type of document. For example, the ERM initiated by the mechanical discipline for adapting the K6/K7 instrument list to the US ABWR was limited to a perfunctory project/administrative review and did not include a review by GE's C&I discipline.

An internal QA audit performed by GE during March 1991 - May 1991 noted that the K6/K7 P&ID revisions were being issued after making additional changes for inclusion as amendments to the standard safety analysis report without performing independent reviews of these drawings. In response to this audit finding, a schedule was prepared to perform independent reviews of the P&IDs. GE stated that the P&IDs used in the SSAR were alpha revisions, and did not require independent reviews. GE plans to review all the SSAR chapters after incorporating NRC Staff's comments and reissue them during the summer of 1992.

Though GE performs periodic QA program audits of the Hitachi and Toshiba programs, no technical audits of the design details such as calculations are performed. No independent design verification (in addition to the designers'

supervisor) was found in the records reviewed. Only those common engineering documents that are signed off by GE get a minimal technical review by GE staff to assure the reasonableness of the information and that it falls within expected values.

2.0 STATUS OF DESIGN DOCUMENTATION IN SUPPORT OF THE SSAR

The design documentation applicable to the US ABWR are listed in the ABWR Certification Program Master Parts List (MPL) Index. The team requested samples of the documents in the MPL for review and these documents were readily retrievable. Most of the documents in the MPL were K6/K7 design documents that were reissued for the US ABWR. As previously described, this dedication of K6/K7 documents was limited to adding a new cover sheet and identifying in a DAL the aspects of the design that required modification if the ABWR were to be built in the U.S.

For all the disciplines, no formal, approved calculations were available for the RHR and RCW systems. The team was told that this detailed design information existed in Japan.

2.1 Civil/Structural

During the team's visit, NRC civil/structural engineering staff were reviewing seismic design adequacy of the various plant buildings. Except for a few higher level documents related to the reactor building and containment for K6/K7, there were no other design documentation listed in the MPL in the civil/structural area. These documents invoked Japanese codes and standards. The team concluded that significantly more design information would be required in the civil/structural area for performing a design inspection.

The only US ABWR specific document reviewed by the team was a stress report prepared by Bechtel to evaluate the adequacy of the K6/K7 containment and reactor building design against US standards. Bechtel used a fairly coarse finite element model to perform the analysis, and reached the conclusion that the Japanese design would not meet the US standards without modifications. The modifications are minor in nature, but still represent a major task to have them correctly implemented. The Bechtel study also recommended that a more detailed finite element model should be developed to enable a better understanding of the K6/K7 design. The analysis using a detailed model could identify the need for additional modifications required to meet the US codes and standards.

2.2 Mechanical

In the mechanical area, the K6/K7 design has progressed to where equipment requirement specifications for major pieces of equipment (e.g., pumps, heat exchangers) have been prepared. Many of the design documents associated with K6/K7 are currently being converted over to the US ABWR.

Status of the design record files for the various systems vary depending upon whether GE has lead design responsibility for the system or if lead design resides with one of the other K6/K7 partners, Hitachi or Toshiba (H/T). In the case of RHR, since GE was originally the lead designer (lead design

responsibility has subsequently shifted to H/T), the design record file contains more detail than the file for RCW for which H/T always had the lead. For example, the design record file for RHR contains some original calculations or computations, while in the case of RCW, the file mostly contains information on the review by GE of upper level documents provided by H/T. In the case of both systems, however, the current calculations of record reside in Japan.

The mechanical portions of the system design of RHR has progressed to an extent that preliminary equipment specifications have been prepared for the heat exchangers and pumps. The process flow diagram (PFD) needs additional detail, particularly where changes have been made to the K6/K7 design, such as, addition of the cross-connect to fire-protection system for the AC Independent Water Addition Mode. Also, design work is needed in the area of other proposed changes, such as automatic initiation of suppression pool cooling discussed in a DAL (the current design requires manual initiation of suppression pool cooling).

In the case of the RCW, a significant amount of design work remains because of the addition of a third heat exchanger to each loop, and also because of relocation of major equipment (pumps and heat exchangers) to the Control Building. Flow network calculations need to be performed, the PFD needs to be revised for the new configuration, and the sizing of major components needs to be confirmed.

2.3 Piping and Components

Just prior to the team's visit to GE offices, another group of NRC Staff visited GE to review the piping design criteria and several samples of piping analyses. In order to complement this staff audit, the team assessed the status of design documentation to support preparation of procurement specifications for piping and components such as pumps, heat exchangers, motor operated valves, etc. For the RHR and RCW systems, except for locations for major components, no piping arrangement or piping qualification documents were available. Design information from K6/K7 were available to prepare preliminary design specifications for pumps, heat exchangers and valves, provided this information was appropriately converted from the Japanese design requirements to those that are applicable to the US ABWR.

GE stated that the seismic analyses methodology used by H/T for qualifying piping and components for K6/K7 were less conservative than the US requirements because vertical seismic coefficients were used instead of vertical floor response spectra for analyzing piping inside the containment, and the horizontal seismic floor response spectra at the piping center of gravity were used for piping subsystem analysis instead of the spectra at the highest support point of the piping. Therefore, the K6/K7 piping design would require revision to consider these changes in addition to other changes included in the design action list.

For the US ABWR, analysis of pipeline breaks to evaluate effects of jet forces and flooding has not been performed.

2.4 Control and Instrumentation

The current available MPL documents related to the control and instrumentation for the RHR and RCW systems and the interfacing systems such as essential multiplexing system (EMS), safety system logic and control (SSLC) and process radiation monitoring, were limited to upper-level functional requirements documentation and did not include calculations, performance requirements, realtime software descriptions, or schematic diagrams.

Generally, the available documentation appeared well prepared and organized but in itself did not support in much depth the physical realization of the hardware design or realization of software structure and software design. There was insufficient information to substantially define a prototype system for innovative technology.

The type of higher level documents available included a preliminary instrument list identifying only the process parameter, interlock block diagrams, methodology for establishing instrument nominal setpoints and Technical Specification limits, task analysis and man-machine interface requirements, general verification and validation criteria, upper level system requirements for the EMS and SSLC.

The available upper-level design documentation generally appeared well structured and organized, but a very cursory review of the documents by the team identified several apparent inconsistencies, indeterminate design attributes, and potential concerns. For example, the interlock block diagrams did not show the mid-travel torque switch protection for throttling control of certain MOVs. Ambiguous requirements existed for location of pressure taps, flow and temperature accuracy requirements for heat exchanger performance measurements, and location of temperature elements to ensure stability of system temperature control were specified.

The RCW P&ID showed analog rather than digital implementation of the control and instrumentation, and the temperature control mode was not identified. It appeared that the P&ID had not been reviewed in any depth by the C&I discipline.

The requirements in the upper-level documents were so general in nature that a wide variety of designs could be implemented within the constraints specified in these documents, including questionable or unacceptable configurations. Also there was no definition or restraint identified for incorporating new technologies. For example, the criteria presumably would permit the use of neural networks, adaptive systems, or 100 MHz processors. Consequently, there are many unknown aspects to the design. At this time, it is impossible to judge whether the implementing technology would be sufficiently proven or could have an adverse impact on interfaces. These, yet unspecified, aspects of the C&I design have been recognized by the staff and will be addressed by appropriate design acceptance criteria (DAC).

2.5 Electrical

As described for the other disciplines, preliminary upper-level documents applicable to the K6/K7 design have been included in the MPL for the electrical discipline. The available documentation consisted of a

comprehensive electrical load tabulation estimated from K6/K7 design, location drawings for major electrical equipment, single line diagrams, and design specifications for electrical power distribution system, DC power system and raceway system. These documents were preliminary in nature and lacked many important design criteria and requirements.

Calculations were not available to support any aspect of the electrical design. The diesel generator loading and sequencing provided in the SSAR could not be substantiated since no calculations were available. A simple data base spreadsheet is currently used by GE to add up electrical loads taken from system design specifications. No calculations for voltage dip based on motor inrush current during load sequencing were available. It appeared that the diesel generator load sequencing table in the SSAR did not include for margins to accommodate valve stroke times and tolerances for timing of load sequences. Therefore, the time to rated RHR flow could be longe. than the assumed value in the accident analyses.

The procurement specifications for metal clad switchgears, power centers and motor control centers have not been developed. If the K6/K7 specifications are to be used, reconciliation of Japanese standards, equipment ratings, device internal heating limits, bus bar bracing, ratings for short circuit currents, etc. must be done.

The design specification for electrical power system design though more comprehensive than other electrical documents, lacks many specific design requirements such as maximum acceptable voltage swings on electrical buses, cable ampacity, and derating requirements, and use of ground overcurrent protective relays in addition to phase overcurrent relays.

The DC power supply system design specification does not specifically cite the applicable standards, but merely states "Japan Industrial Standard," "ANSI," "IEEE" or "NEMA" without listing the number or title of the standards. This document lacks many specific design requirements such as maximum and minimum DC system voltage and maximum temperature to limit available short circuit current.

The design specification for safety-related and non-safety-related electrical raceways lacks technical details such as conduit types, cable fill limitations, and installation requirements.

The electrical single line diagrams do not include details such as loads, cable sizes, and bus and circuit breaker ratings.

Enclosure 2

Design Process Assessment Team

The team consisted of the following:

S. Malur	RSIB	Team Leader
H. Wang	RSIB	Civil/Structural
J. Leivo	Consultant	Control & Instrumentation
A. DuBouchet	Consultant	Piping & Components
C. Crane	Consultant	Electrical
T. DelGaizo	Consultant	Mechanical

R. Pierson attended the entrance meeting, and participated in the discussions with the GE staff on March 30-31, 1992. E. Imbro attended the exit meeting, and participated in the discussions with the GE Staff on April 1-2, 1992.