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GE Nuclear Energy

ABWR

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Subject CONTAINMENT HYDRODYNAMIC LOADS

Message ATTACHED PLEASE FIND:

- ATTACHMENT A – SRV LOADS (5/6/92 MEETING)
- ATTACHMENT B – POOL SWELL LOADS (5/6/92 MEETING)
- EXHIBIT B – SECY-91-355 ISSUE (10)
- ATTACHMENT C – CHUGGING AND CONTAINMENT LOADS (5/6/92 MEETING)

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ATTACHMENT A

GE response to DSER open items, related to SRV actuation loads, which were identified and discussed in GE/NRC meetings on May 6, 1992 at the NRC office in Rockville. This response is consistent with the GE/NRC discussion in these meetings.

OPEN ITEMS

1. Address SRV loads resulting from valves reopening before the tailpipe is cooled and completely vented.

2. Were the suppression pool temperature limits considered in analyzing steady state SRV steam flow conditions?

3. The SRV discharge line X-quenchers are identical to those used in the Mark II and Mark III designs. What are the benefits of this design to the ABWR? The discharge loads for the ABWR were calculated as they were for the Mark II and Mark III designs. Is this appropriate.

RESPONSE

1. In defining SRV actuation loads for design evaluation of ABWR containment, both first actuation and subsequent actuation (i.e., valve reopening before the tailpipe is cooled and completely vented) cases were considered and analyzed. These loads were determined and defined in accordance with the guidelines specified and documented in NUREG-0802.

2. Suppression pool temperatures associated with steady state steam

condensation are no longer needed and, hence, were not considered. Recent studies (performed by GE for BWR Owners Group) have concluded that suppression pool temperature limits (specified in NUREG-0783) associated with steady state SRV steam flow conditions are not needed. Steam condensation loads with quencher discharge devices over the full range of pool temperature up to saturation are low compared to loads due to SRV discharge line air clearing and LOCAs which will be considered and defined for the ABWR containment design evaluations. Results and conclusions from these recent studies are described and discussed in NEDO-30832, Class I, December 1984 ("Elimination of Limit on BWR Suppression Pool Temperature for SRV Discharge With Quenchers), which is being reviewed by the staff. In view of the conclusions from these recent studies, it is now believed that suppression pool temperature limits (NUREG-0783) in analyzing steady state SRV steam flow conditions no longer apply.

However, ABWR design does retain the restrictions on the allowable operating temperature envelope intended to avoid unstable steam condensation, consistent with the restrictions in place for current operating plants. Also, ABWR suppression pool temperature monitoring system conforms to the requirements and guidelines specified in NUREG-0783.

3. ABWR design utilizes the same X-quencher discharge device as that used in Mark II and Mark III plants. The development and design of this quencher device was based on many years of testing and development work, and performance of this device has been is well tested and confirmed through scaled and large-scale (including in-plant tests) testing. This quencher device has been demonstrated to be very effective in minimizing air-clearing pool boundary loads, and in providing a stable steam condensation process during steady state SRV steam flow conditions. Therefore,

by utilizing this well tested quencher device, ABWR design benefits from the many years of testing and development work.

For detail on this subject, see attached EXHIBIT A

EXHIBIT A

SRV Actuation Pool Boundary Hydrodynamic Loads

A summary description of SRV actuation hydrodynamic loads and the methodology used in calculating and defining such loads for the ABWR design are described here.

1. INTRODUCTION

During the actuation of a safety relief valve (SRV), the air initially contained inside the SRV discharge line is compressed and subsequently expelled into the suppression pool by the SRV blowdown steam entering the SRV line. The air exits through holes drilled into an X-quencher device which is attached to the SRV discharge line. The X-quencher discharge device promotes effective heat transfer and stable condensation of discharged steam in the suppression pool, thereby minimizing suppression pool boundary loads.

ABWR design utilizes the same X-quencher discharge device as that used in Mark II and Mark III designs, shown in Figure A-1. The design configuration of this quencher device is based on many years of testing and developed work, and performance of this quencher device has been well tested and confirmed through scaled and large-scale (including in-plant tests) testing. This discharge device has demonstrated its effectiveness in minimizing air-clearing pool boundary loads, and also provides a smooth and stable condensation process during steady state SRV steam flow conditions. Therefore, by employing this well designed and tested X-quencher discharge device, ABWR design benefits from the many years of testing and development work. A reduction in the pool boundary loads will help in reducing the structure design cost, and a stable steam condensation process

should be of help in plant operation.

Figure A-2 shows the quencher azimuthal locations in the suppression pool. This arrangement distributes low, intermediate and high pressure set-point valves uniformly around the pool region to preclude concurrent adjacent valves actuation.

2. QUENCHER DISCHARGE LOADS

After the air exits into the suppression pool, during the actuation of SRV, the air bubbles (discharging from holes in the quencher arms) coalesce and oscillate as Rayleigh bubble while rising to the pool free surface. The oscillating air bubbles produce hydrodynamic loads on the pool boundary and drag loads on structures submerged in the pool. After the air has been expelled, steam exits steadily and condenses in the pool. This condensing steady state SRV steam flow has been found to produce negligible pressure loading on the pool boundary, as evident from testing of this X-quencher discharge device

The calculation methodology used for defining the quencher air-clearing pool boundary loads for the ABWR design is based on and consistent with the staff approved methodology (documented in NUREG-0802) for Mark II and Mark III containments equipped with this X-quencher discharge device. This methodology is based directly on empirical correlations which were developed from and based on data obtained from mini-scale, small-scale, and large-scale (including in-plant tests) tests conducted to develop a load definition methodology for X-quencher discharge loads during SRV actuation. This methodology defines correlations which can be used to calculate the magnitude of quencher air clearing loads on pool boundary as a function of several key parameters. The key parameters are of two categories: i) which are related to the X-quencher device configuration, and ii) which are related to the plant specific SRV discharge line configuration

This Mark II and Mark III methodology defines procedures for defining the pool boundary loads due to the first and subsequent SRV actuation (valve reopening before the tailpipe is cooled and completely vented) conditions, and the loads due to multiple valve actuation conditions (when more than one quencher bubble exists in the pool).

3. ABWR DESIGN QUENCHER DISCHARGE LOADS

3.1 Air Clearing Pool Boundary Loads

Quencher discharge pool boundary loads for design evaluation of the ABWR design are defined in accordance with the methodology defined in NUREG-0802. In defining the design loads, both single and multiple valve discharges for first and subsequent actuations were considered and analyzed.

The multiple valves discharge case covers the events in which all SRVs actuate which would result in most severe loading condition on the pool boundary. For plant transients which result in rapid RPV pressure increase rates, the valves are actuated almost simultaneously. However, variation in time of actuation, valve opening time, and individual discharge line lengths will introduce differences in phasing of the oscillating air bubbles in the suppression pool. Presence of difference in phasing among the oscillating air bubbles is found to have a mitigating effect or the pool boundary loads.

As a conservative approach, ABWR design does not consider and take credit for the mitigating effect due difference in phasing among the oscillating air bubbles. Multiple valves discharge case for the ABWR design considers and includes two loading conditions which represent

most severe symmetric and asymmetric loading conditions.

a. All oscillating air bubbles from all valves in phase - the most severe symmetric loading condition.

b. Oscillating air bubbles in one half of the pool 180° out of phase to those in the other half of the pool - the most severe asymmetric loading condition.

3.2 Steady Steam Condensation Conditions

After air discharge through the SRV line is completed, steady steam flow from the quencher is established. Discharged steam condenses in the immediate vicinity of the discharge device. Available test data indicate that SRV steady steam discharge through X-quencher device is a stable steam condensation process resulting in an insignificant loading on the pool boundary, as shown in Figure A-3. These loads are found to be substantially low compared to loads due to quencher air clearing and LOCA pool boundary loads, Therefore, dynamic loading condition during quencher steady state steam condensation process is not considered and defined for the ABWR containment design evaluation.

Operating practice of earlier BWRs, in anticipation that extended steam blowdown into the pool will heat the pool to a level where the condensation process during steady state SRV steam flow conditions may become unstable, restricts the allowable operating temperature envelope of the pool in the Technical Specifications so to avoid occurrence of unstable steam condensation. NUREG-0783, currently, specifies acceptance criteria related to the suppression pool temperature limits for steady state steam condensation condition, as well as requirements and guidelines for the suppression pool temperature monitoring system.

Recent studies (performed by GE for BWR Owners Group), subsequent to

the issuance of NUREG-0783, have concluded that steady steam flow through X-quencher devices is expected to be a stable and smooth condensation process over the full range of pool temperature up to saturation. Results and conclusions from these recent studies are described and discussed in NEDO-30832, Class I, December 1984 ("Elimination of Limit on BWR Suppression Pool Temperature for SRV Discharge With Quenchers"), which is being reviewed by the staff.

In view of conclusions from these recent studies, it is now concluded that suppression pool temperature limits (specified in NUREG-0783) in analyzing steady state SRV steam flow conditions no longer apply, and, hence, they were not considered for the ABWR design. However, ABWR design does retain the restrictions on the allowable operating temperature envelopes, similar to those in place for current operating plants. This will assure a more safer plant operation. Also, the ABWR suppression pool temperature monitoring system conforms to the requirements and guidelines specified in NUREG-0783.