GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

March 4, 1994 Docket No. 52-001

Chet Poslusny, Senior Project Manager
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of the Nuclear Reactor Regulation

Subject: Submittal Supporting Accelerated ABWR Schedule - **EPG Issue on HTCL**

Dear Chet:

Enclosed is an SSAR markup addressing the subject issue.

Please provide a copy of this transmittal to Tony D'Angelo.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

cc:	Alan Beard	(GE)
	Norman Fletcher	(DOE)
	Joe Quirk	(GE)
	Umesh Saxena	(GE)

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For structure evaluation of the horizontal vent pipe and pedestal, an upward load, based on the HVT test data, is conservatively defined as shown in Figure 3B-27.

For building structure response analysis for the evaluation of RPV and its internals, the horizontal vent upward load is specified as shown in Figure 3B-28. To bound symmetrical and asymmetrical loading conditions, the following two load cases will be considered and analyzed.

(1) Upward load on the pedestal wall simultaneously at all top 10 horizontal vents

(2) Upward load on the pedestal wall simultaneously at top five vents in one-half side of pedestal

INSERT (A)

3B.5 Submerged Structure Loads

Structures submerged in the suppression pool can be subjected to flow-induced hydrodynamic loads due to LOCA and SRV actuations.

During a LOCA, steam/water mixture rapidly escapes from the break, and the drywell is rapidly pressurized. The water initially in the vent system is expelled out into the suppression pool. A highly localized induced flow field is created in the pool and a dynamic loading is induced on submerged structures. After the water is expelled from the vent system, the air initially in the drywell is forced out through the horizontal vents into the suppression pool. The air exiting from the vents forms expanding bubbles which create moderate dynamic loads on structures submerged in the pool. The air bubbles cause the pool water surface to rise until they break through the pool water surface. The pool surface water slug decelerates and falls back to the original pool level Steam/water mixture from the break soon fills the drywell space and is channeled to the pool via the vent system. Steam condensation starts and the vibratory nature of pool water motion causes an oscillatory load on submerged structures.

The CO loading continues until the pressure in the drywell decreases. This is followed by a somewhat regular but less frequent vibration called chugging (CH). During the CH period, a high frequency spike is propagated, which causes an acoustic loading on submerged structures.

During SRV actuations, the dynamic process of the steam blowdown is quite similar to LOCA steam blowdown but the induced load is mitigated by the X-quencher device attached at the end of each discharge device. Two types of loads are important. One is due to the water jet formed at the confluence of the X-Quencher arm discharges and another is due to the four air bubbles formed between the arms of the X-Quencher These air bubbles are smaller in size than the LOCA air bubbles, reside longer in the pool, and oscillate as they rise to the free surface of the pool.

INSERT A

3B.4.4 RCIC Turbine Exhaust Steam Condensation

The Reactor Core Isolation Cooling (RCIC) system, which forms a part of the Emergency Core Cooling Systems (ECCS), will maintain sufficient reactor water inventory in the event that the reactor vessel is isolated and the feedwater supply unavailable. The RCIC system injects water into a feedwater line, using a pump driven by a steam turbine. The steam turbine is driven with a portion of the decay heat steam from the reactor vessel and the turbine exhaust steam is piped into the suppression pool where it is condensed. The RCIC system is designed to perform its intended function without AC power for at least 2 hours with a capability up to 8 hours.

In view that the turbine exhaust steam discharges and condenses in the suppression pool and the expected long duration of RCIC operation, there exists a potential for steam condensation loading on the pool boundary. Significance of such potential loading on the pool boundary (steel liner, in specific) was examined, and it was determined that this loading condition will be well bounded by the LOCA steam condensation design loads.

3B4.4.1 Exhaust Steam Condensation Loading

The RCIC system is a safety system, consisting of a steam turbine, pump, piping, accessories, and necessary instrumentation. The steam turbine exhaust steam piping is ASME Code Class 2 piping, as noted in the RCIC P&ID in SSAR Figure 5.4-8. To minimize exhaust steam line vibration and noise levels, the discharge end of the turbine exhaust line will be equipped with a condensing sparger. The sparger design configuration will be similar to that currently used successfully for the operating BWRs.

The condensing sparger is expected to produce a very smooth steam condensation operation resulting in low pressure fluctuations in the pool, which would imply low pressure loading on the pool boundary. During RCIC operation, steam mass flux in the neighborhood of about 48 kg/m^2-sec are expected, which should assure smooth steam condensation process. During the extended RCIC operation, condensing exhaust steam will bring the pool to high temperature. At high pool temperatures, long plumes consisting of a random two-phase mixture of entrained water and steam bubbles are expected to exist. As reported in Reference 3B-16, the condensation of the steam within such a mixture will not give rise to large bubbles that drift into a cooler region of the pool and suddenly collapse which could transmit significant loads to the pool boundary.

Therefore, in view of above, steam discharge through the condensing sparger is expected to be a smooth condensation process which would result in low pressure fluctuation loading on the pool boundary. Steam condensation process at the single exhaust discharge location in the pool will give rise to an asymmetric loading condition on the pool boundary. This expected asymmetric loading condition, which is expected to be a low pressure fluctuation loading, should be bounded by the LOCA steam condensation (CO and Chugging) loads defined for the ABWR design. Further, the ABWR design load definition specifies a bounding asymmetric load case which assumes vents in one half chugging 180° out of phase with the other half vents. This is a conservative representation of asymmetric loading.

In summary, it is concluded that steam condensation loads associated with the RCIC turbine exhaust steam discharge (via condensing sparger) to the pool will produce low pressure fluctuation loads on the pool boundary. Such loads should be well bounded by the LOCA steam condensation loads. The turbine exhaust piping, being designated as ASME Class 2 piping, shall be designed to retain its pressure integrity and functional capability.

3B-2 General Electric Company, *Caorso SRV Discharge Tests Phase I Test Report*, NEDE-25100-P, May 1979.

3B-3 General Electric Company, *Caorso SRV Discharge Tests Phase II ATR*, NEDE - 25118, August 1979.

3B-4 GESSAR II, Appendix 3B, Attachment A, 22A7007, 1984.

3B-5 General Electric Company, *Elimination of Limit on BWR Suppression Pool Temperature For SRV Discharge With Quenchers*, NEDO - 30832, Class I, December 1984.

3B-6 McIntyre, T. R. et al., *Mark III Confirmatory Test Program One-Third Scale Pool Swell Impact Tests - Test Series 5805*, General Electric Company, NEDE - 13426P, Class III, August 1975.

3B-7 General Electric Company, *Horizontal Vent Confirmatory Test, Part I*, NEDC - 31393, Class III, March 1987.

3B-8 Sonin A. A., *Scaling Laws In Small-Scale Modeling of Steam Relief Into Water Pool*, ASME Winter Meeting, Chicago, November 1980.

3B-9 Dodge, F. T., *Scaling Study of the GE PSTF Mark III Long Range Program, Task 2.2.1', SwRI*, General Electric Company Report NEDE - 25273, March 1980.

3B-10 Mark II Containment Program, *Generic Chugging Load Definition Report*, NEDE-24302-P, Class III April 1981.

3B-11 F. J. Moody, *Analytical Model for Estimating Drag Forces on Rigid Submerged Structures Caused by LOCA and Safety Relief Valve Ramshead Air Discharges*, NEDE-21471; revised by L. C. Chow and L. E. Lasher, September 1977.

3B-12 L. E. Lasher, *Analytical Model for Estimating Drag Forces on Rigid Submerged Structures Caused by Steam Condensation and Chugging*, NEDO-25153, July 1978.

3B-13 T. H. Chuang, L. C. Chow, and L. E. Lasher, *Analytical Model for Estimating Drag Forces on Rigid Submerged Structures Caused by LOCA and Safety Relief Valve Ramshead Air Discharges*, NEDO - 21471, Supplement 1, June 1978.

3B-14 Ernst, *Mark II Pressure Suppression Containment Systems: An Analytical Model of the Pool Swell Phenomenon*, NEDE - 21544-P, General Electric Company, December 1976.

~~3B.4.6~~ ← INSERT 3

INSERT B

3B-15 J-H, Chun and A.A. Sonin, *"Small-scale Simulation of Vapor Discharge into Subcooled Liquid Pools"*, Nuclear Engineering and Design **85** (1985) pp 353-362.

3B-16 Letter, January 20, 1994, General Electric (Jack Fox) to the Staff (Chet Poslusny), *"Containment Emergency Procedure Guidelines Issue on Heat Capacity Temperature Limit (HCTL)"*, Docket No. 52-001.

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determining combined pressure loading on pool boundary due to multiple valve actuation. Pressure loading due to individual SRV will be assumed equal to the largest of pressure loading calculated for individual valves. Pressure loading due to an individual valve is primarily determined by its relief pressure setpiont and dischagre line air volume.The combined pressure loading from multiple valves at an evaluation point will be obtained by SRSS (Square Root of the Sum of Squares) of the individual loads from single valves.

As a bounding and conservative approach for structure evaluation, the multiple valves discharge case will consider and include most severe symmetric and asymmetric load cases. The most severe symmetric load case will assume oscillating air bubbles (from all valves) in phase, and the most severe asymmetric load case will assume one half of oscillating air bubbles 180° out of phase with the other half of oscillating air bubbles. These two load cases will bound all combinations of multiple valve actuation cases.

3B.3.3 Quencher Condensation Performance

After air discharge through the SRV line is completed, steady steam flow from the quencher will be established. Discharged steam condenses in the immediate vicinity of the discharge device. Thermal loads associated with steam jet contact can generally be avoided by appropriate orientation of the discharge device in the suppression pool.

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~~Steam from SRV discharge is completely condensed in the pool. Test data indicate negligible condensation loads for quencher devices, as shown in Figure 3B-7. Also, substantial subscale data has been obtained which shows that the dynamic pressures (loads) decrease as the pool temperature approaches saturation temperature. Reference 3B-5 discusses this subscale data and concludes that steam condensation loads with quenchers over the full range of pool temperature up to saturation are low compared to loads due to SRV discharge line air clearing and LOCA events which will be considered in containment design evaluation.~~

~~Therefore, dynamic loads during the quencher steam condensation process will not be defined and considered for containment evaluation.~~

3B.4 Loss-of-Coolant Accident Loads

In this section, methodologies for calculating the dynamic loading conditions associated with the various LOCA phenomena are presented.

3B.4.1 Pressure and Temperature Transients

A LOCA causes a pressure and temperature transient in the drywell and wetwell due to mass and energy released to the drywell. The severity of this transient loading condition depends upon the type and size of LOCA. Section 6.2 provides pressure and temperature transient data in the drywell and wetwell for the most severe LOCA case

Insert C

Operating practice of earlier BWRs, in anticipation that extended SRV steady steam blowdown will heat the pool to a level where the condensation process may become unstable, a temperature limit for BWR suppression pools was established. This pool temperature limit, specified in NUREG-0783, was established because of concern that unstable steam condensation at high pool temperature could result in high loads on containment structure. Although quencher discharge devices (like the X-quencher) were found to produce smooth steam condensation process, at the time the pool temperature limit was established there were insufficient data available to confirm that quenchers were effective in mitigating loads due to unstable steam condensation process. NUREG-0783 currently specifies acceptance criteria related to the suppression pool temperature limits for steady state steam condensation condition for the quencher discharge devices

Recent studies, subsequent to the issuance of NUREG-0783, conclude that steady steam flow through quencher devices (like the X-quencher) is expected to be a stable and smooth condensation process over the full range of pool temperature up to saturation. It is also concluded that the condensation loads for steam discharge through a quencher device are approximately an order of magnitude less than the loads from equivalent straight pipes. These recent studies are described and discussed in Reference 3B-5.

Subsequent to the studies reported in Reference 3B-5, there were additional test data from quencher discharge tests at high pool temperatures. These tests, reported in Reference 3B-15, showed a long, steady, turbulent, forced plume which consisted of a random two-phase mixture of entrained water and steam bubbles. This additional data, which showed formation of a long continuous steam plume at high pool temperatures, raised an additional concern. It was postulated that large continuous steam plumes may give rise to large bubbles that drift into a cooler region of the pool and suddenly collapse which could transmit significant loads to the pool boundary.

This additional concern was evaluated in a recent study, and it was determined that the continuous plume was not a transient flow shedding large coherent bubbles which might drift away and collapse in a cooler region of the pool. This recent study, described in detail in Reference 3B-16, concludes that the condensation process with SRV discharges through quenchers (like the X-quencher) into the suppression pool would result in low amplitude loads for all suppression pool temperatures.

In view of findings and conclusions from these recent studies discussed in above, it is concluded that suppression pool temperature limits (specified in NUREG-0783) for SRV discharge with quenchers are no longer necessary. Therefore, given that the ABWR design utilizes X-quencher discharge devices, the pool temperature limit specified in NUREG-0783 were not considered. However, ABWR design retains the restrictions on the allowable operating temperature envelope of the pool, similar to those in place for operating BWRs.

Further, the studies in Reference 3B-5 conclude that steam condensation loads with X-quenchers over the full range of pool temperature up to saturation are low compared to loads due to SRV discharge line air clearing and LOCA events. Therefore, considering that ABWR design considers SRV air clearing and LOCA steam condensation loads for containment design evaluation, dynamic loads during the quencher steam condensation process will not be defined and considered for containment design evaluation.