Reactor Controls, Inc.

October 30, 1981

Director Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Reactor Controls, Inc.
Letter dated 14 October 1981

Reference: Telecon 26 October 1981
Mr. Bill Mills, NRC and
Mr. J. C. Millett, RCI

Gentlemen:

Per your request during the above referenced telephone conversation, we are reiterating the general contents of that conversation by submittal of this letter. The intention is to describe the analysis method and results leading to the submittal to you of our subject letter dated 14 October 1981.

Description of Control Rod Drive Hydraulic System Insert/Withdraw Piping Water Hammer Analysis and Results

Introduction

Analysis for the effects of waterhammer has been completed for the Grand Gulf CRD system. Analysis results on the original design (pre "New Loads") indicated a significant impact on total stresses and the need for major pipe support modification.

Method

Waterhammer loads are generated using the computer program RELAP which develops pressure time histories throughout the piping, and the computer program BLAZER which converts the pressure time histories to force time histories. These programs are applied to piping going from the Hydraulic Control Units (HCU's) to the Control Rod Drive (CRD) housings (see Figure 1 for typical configuration). The piping is then divided into segments for a force time history piping stress analysis using the computer program TPIPE. Resulting pipe support loads are for single pipes passing through large support frames which typically support about one-fourth of the 386 insert and withdraw lines.

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Therefore, analysis of the support frame requires combining the effects of many pipes based on the results of a few. Two separate scram events were analyzed; start-up scram and normal scram. Start-up scram occurs during pre-operational tests or during start-up of the Nuclear Boiler with the Reactor Pressure Vessel (RPV) at lower than normal operation or ambient pressure. The normal scram occurs during normal operation with the RPV at normal operating pressure. The critical waterhammer loading event for the insert piping is the start-up scram (the withdraw lines are affected much less severely and are not felt to be critical). The start-up scram produces high loads because of a high pressure differential across the scram valve, V126. The normal scram produces loads half the magnitude of those encountered in the start-up scram because of lower differential pressures.

The start-up scram RELAP model incorporated the following assumptions of significance:

1. Accumulator is at 2000 psig while the normal operating pressure is 1750 psig, the 2000 psig is a possible condition and there is apparently limited control on this variation.

2. Valve opening time is 0.02 sec. This is the fastest design opening time.

The waterhammer loads are the result of rapidly moving (sonic velocity) pressure transients in the piping systems. The pressure transients are a function of the valve opening time and the pressure differential across the valve.

With an instantaneously opening valve, the pressure transient could theoretically reach a peak of the sum of the static pressure plus the pressure differential. For the start-up scram:

$$P \langle \text{transient} \rangle = P \langle \text{static} \rangle + P \langle \text{differential} \rangle$$

$$P \langle \text{transient} \rangle = 2015 \text{ psia} + (2015 \text{ psia} - 30 \text{ psia})$$

$$P \langle \text{transient} \rangle = 4000 \text{ psia}$$

The RELAP analysis calculated maximum pressure transients of 3750 psi.

<u>Analysis Considerations</u>

1. Start-up Scram-Insert Lines

Valve opening time (V126)	0.02 sec.
Operating pressures	
Accumulator to V126	2015 psia
CRD housing to V126	45 psia minus static head
Operating temperature	80 degrees F
CRD piston location	1/4 withdrawn
Pipe contents	water
Structural damping	1% of critical damping
Code design condition	upset

Analysis Considerations (continued)

2. Normal Scram-Insert Lines

Valve opening time (V126)	0.02 sec.
Operating pressures	
Accumulator to V126	2015 psia
CRD housing to V126	1115 psia minus static head
Operating temperatures	
Accumulator to V126	80 degrees F
CRD housing to V126	150 degrees F
CRD piston location	Fully withdrawn
Pipe contents	water
Structural damping	1% of critical damping
Code design condition	upset

3. Normal Scram - Withdraw Lines

Valve opening time (V127)	0.02 sec.
Operating pressures	
CRD housing to V127	1105 psia minus static head
Scram header to V127	14.7 psia plus static head
Operating temperatures	
CRD housing to V127	150 degrees F
Scram header to V127	80 degrees F
CRD piston location	fully withdrawn
Pipe contents	water
Structural damping	1% of critical damping
Code design condition	upset

4. Start-up Scram - Withdraw Lines

Waterhammer loads considered negligible because pressure differential across V127 is less than 30 psia.

Time phasing of piping reaction load studies based on geometric considerations were performed to reduce the total load on the bundle support, as opposed to assuming peak loads occurring simultaneously at each support location.

Analytical considerations not included in the analysis: depressurization of the Hydraulic Control Nitrogen Accumulator, movement of the CRD, valve opening time history including orifice effects. (The valve orificing effect was not analyzed contrary to our phone conversation with NRC.) The primary reason these parameters were not considered was due to the limitation of RELAP. It is felt that these would give varying degrees of relief most on the order of 2-5% reduction maximum.

Analysis Results

The results of the piping stress analysis for the start-up scram show that piping is over stressed by factors as high as six times ASME Code allowables due to pressure peaks and high displacement effects. Loads on supports in the 2000 to 3000 pound per pipe range cause stresses in structural members and pipe clamps to exceed allowables by 500% and 200% respectively.

The analysis predicts the most severe pipe stresses at HCU valves and pipe bends along the CRD insert piping. Support loads are highest at locations upstream and downstream of pipe bends and at in-line anchors e.g. at Drywell Wall.

Solutions to pipe stresses and structural stresses have required the addition of axial insert pipe restraints. The majority of CRD insert and withdraw pipe supports were originally designed to allow free thermal growth of piping in the axial direction. The addition of axial pipe reaction load plus increased lateral loads has required extensive modification to the supports.

Pre-op Scram Test Monitoring and Observations

Early in the analysis of water hammer it was felt that the analytical results were grossly over predicting the transient effects. In an effort to provide a bench mark for calculated pressure peak and time history occurring during an actual scram, pressure transducers were inserted into the vent valve above the HCU's during the Grand Gulf pre-operational scram tests.

The results of the test showed the analytical predictions to be approximately 20% conservative in predicting peak pressures. The conservations are attributed to limitations of RELAP to closely simulate the CRD system parameters and built-in conservatism.

We trust the above information will be helpful to you. If you have further questions, please contact the undersigned.

Very truly yours,

J. C. Millett
Vice President

JCM/jw

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FIGURE 1

SCHEMATIC OF TYPICAL I/W PIPE INSTALLATION