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CALCULATION TITLE PAGE

Client: PSEG Nuclear LLC	Page 1 of 13
Project: Hope Creek Decontamination Port	Task No. 1108-0502-0002-00
Title: Harmonic Stress Analysis of Loop 'B' Port	Calculation No. Attach 17 to C-0142

Preparer / Date	Checker / Date	Reviewer & Approver / Date	Rev. No.
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QUALITY ASSURANCE DOCUMENT

This document has been prepared, checked, and reviewed/approved in accordance with the Quality Assurance requirements of 10CFR50 Appendix B, as specified in the MPR Quality Assurance Manual.

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RECORD OF REVISIONS

Calculation No.	Prepared By	Checked By	Page: 2
Attach 17 to C-0142	E.B. [illegible]	[illegible]	

Revision	Affected Pages	Description
0	All	Initial Issue

Note: The revision number found on each individual page of the calculation carries the revision level of the calculation in effect at the time that page was last revised.

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1.0 PURPOSE

The purpose of this calculation is to estimate the alternating stress at the attachment weld of the Hope Creek Reactor Recirculation Loop 'B' decontamination port for a unit input sinusoidal load. The attachment weld developed a crack during plant operation.

2.0 BACKGROUND

The failed decontamination port is located on the suction side of the 'B' Reactor Recirculation Pump within the isolable section of Recirculation piping. The port is designed to be used infrequently during outages to flush water through the Recirculation piping. During normal plant operations, the port is sealed with a bolted blank flange.

The failed port is shown in Figure 2-1. The arrow in Figure 2-1 indicates the crack location.

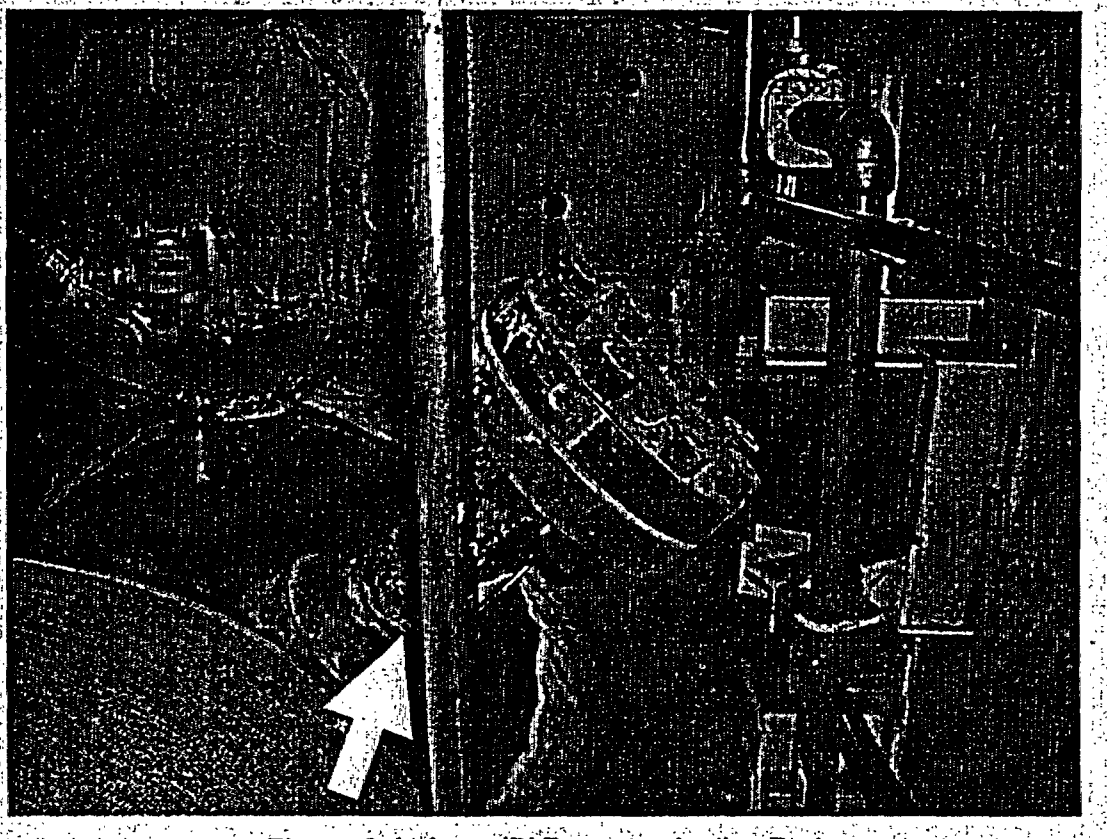

Figure 2-1. Loop 'B' Decontamination Port

3.0 SUMMARY OF RESULTS

The alternating stress is 30 ksi for an assumed 1 g harmonic vibration at the first mode natural frequency.

4.0 ANALYTIC APPROACH

The alternating stress was determined by a harmonic forced response analysis. The harmonic analysis technique is used to determine the steady-state forced response of a linear structure to a load that varies sinusoidally (harmonically) with time. A unit sinusoidal (harmonic) load of 1 g was applied at the first mode natural frequency of 122 hz (Reference 1). The harmonic analysis is linear; consequently the stress results from this calculation can be ratioed to sinusoidal input levels other than 1 g.

The analysis was performed with a three-dimensional finite element model of the port and a section of the Recirculation piping. The model represents one-half of the port with a plane of symmetry through the port axis. The model was developed with the ANSYS computer program (Reference 2). The solid model of the original as-built configuration of the port is shown in Figure 4-1; the finite element model is shown in Figure 4-2. The finite element model is documented in Reference 1.

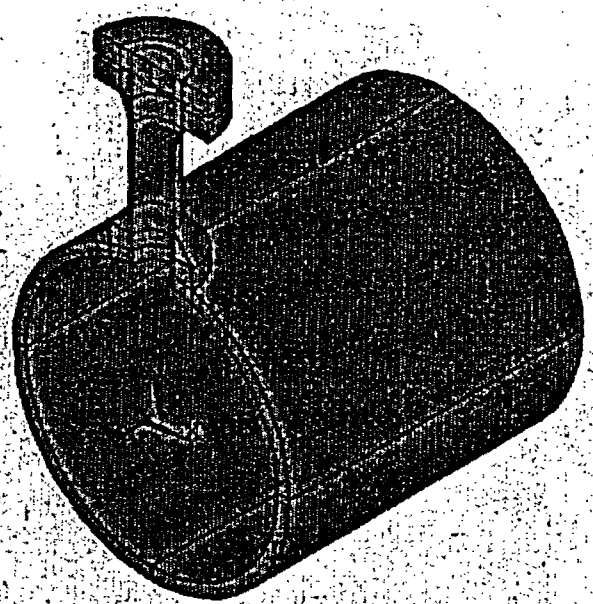

Figure 4-1. Solid Model for Original Decontamination Port

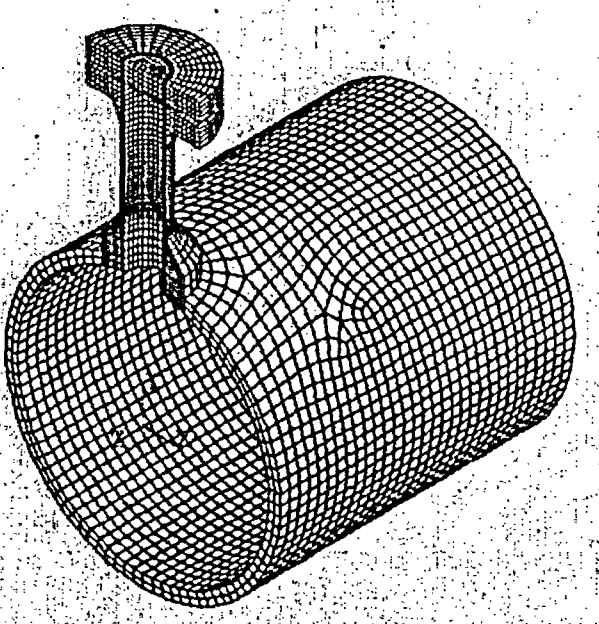

Figure 4-2. Finite Element Model for Original Decontamination Port

5.0 HARMONIC ANALYSIS INPUT

For a sinusoidal displacement with the form:

$$u(t) = A\sin(\omega t)$$

The velocity is:

$$v(t) = A\omega\cos(\omega t)$$

And the acceleration is:

$$a(t) = -A\omega^2\sin(\omega t)$$

To determine the sinusoidal displacement at a frequency, f = 122 hz that will result in an acceleration of 1g, Note that:

$$\omega = 2\pi f = 2\pi 122$$

$$1 * 386.4\ in/sec^2 = -A\omega^2 = -A(2\pi 122)^2$$

$$-A = 0.00066\ inch$$

A sinusoidal displacement of 0.00066 inches was applied as shown in Figure 5-1.

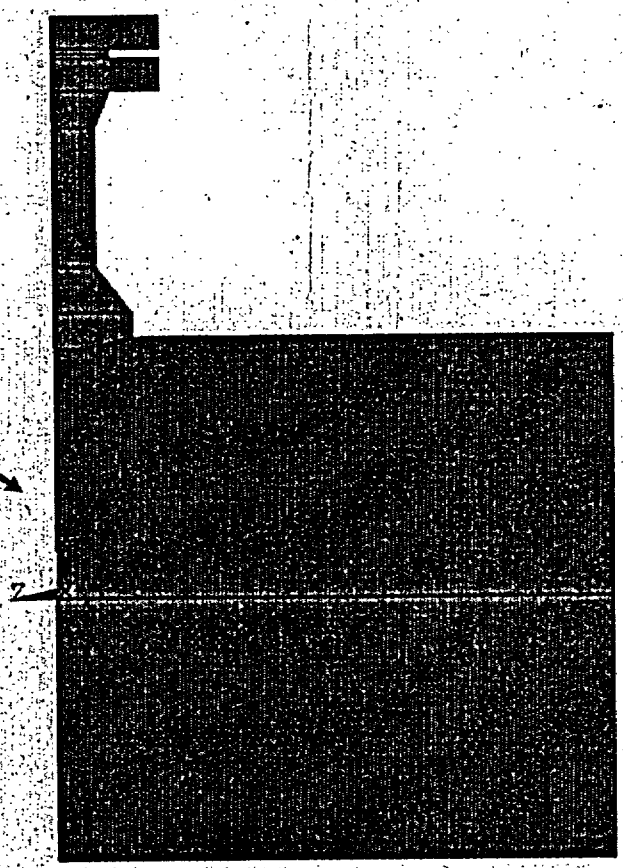

Figure 5-1. Structural Boundary Conditions

5.1 Damping

Regulatory Guide 1.61, Reference 3, provides recommended damping values for seismic analysis of piping systems. Based on the information in Reference 3, a damping value of 1% was used in the harmonic analysis.

6.0 RESULTS

The stress analysis results are provided in color contour plots, Figures 6-1 and 6-2. The stress component in the direction of the decontamination line axis, Sy is shown. This stress component is in the crack opening direction. The peak stress alternates between +30 ksi and -30 ksi. The stress range is therefore 60 ksi and the alternating stress is one-half of the stress range or 30 ksi.

Figure 6-3 shows the stress profile through the thickness of the decontamination pipe wall. The stress varies from 3.6 ksi on the pipe inside diameter to 30 ksi on the pipe outside diameter.

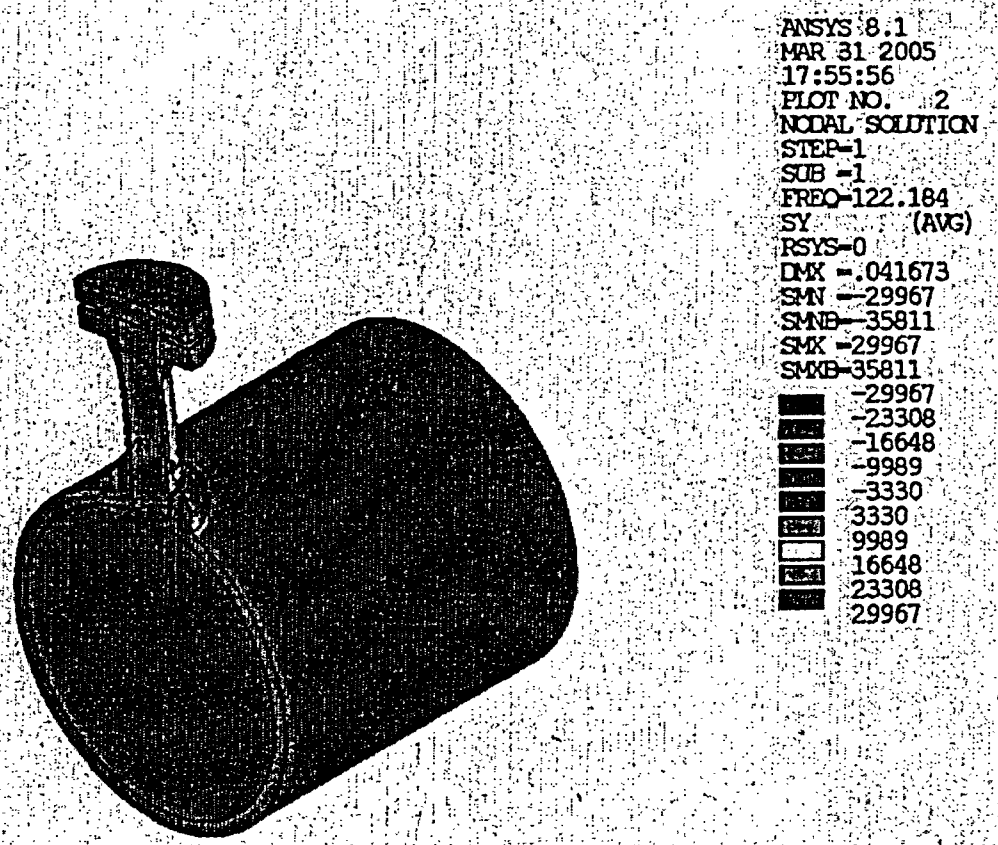

Figure 6-1. Stress in the Crack Opening Direction, Sy

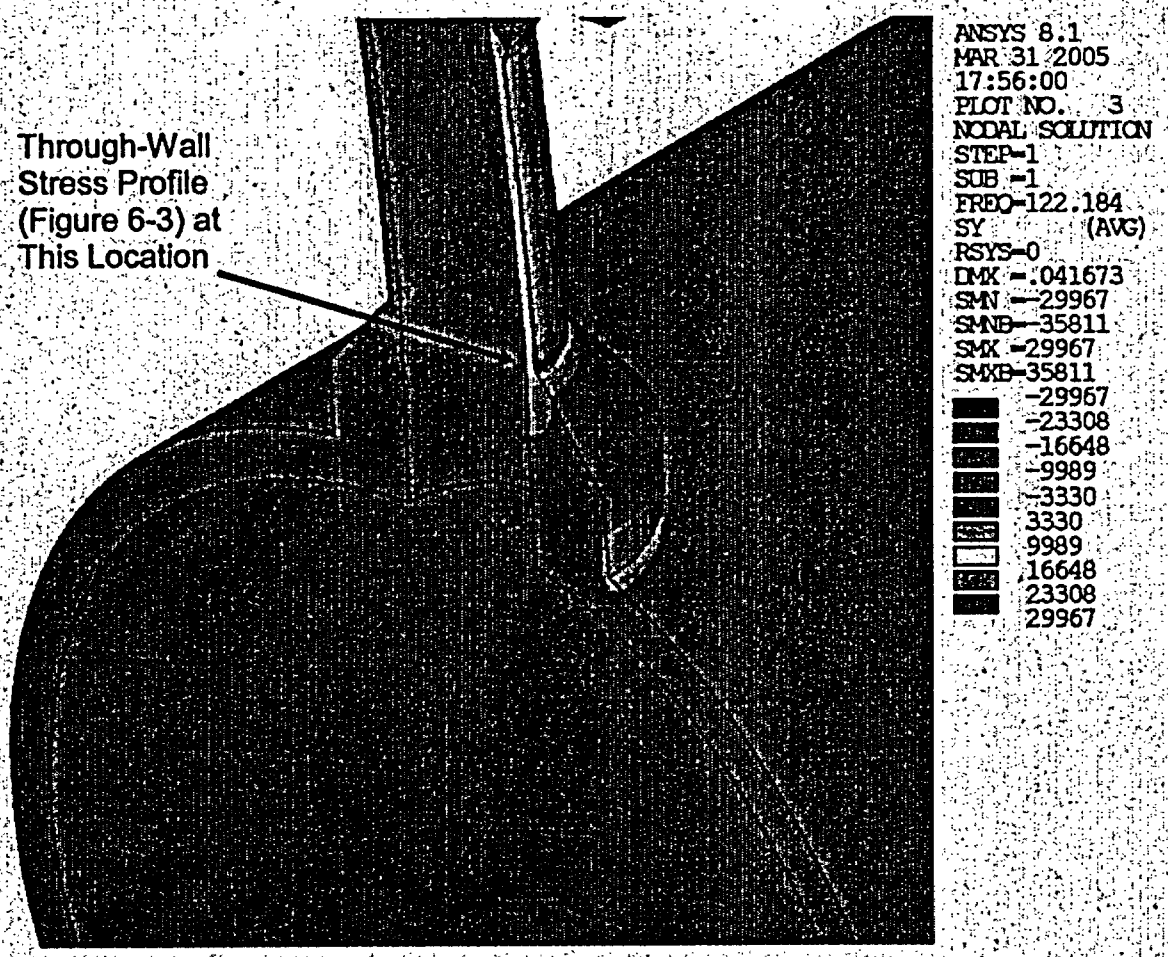

Figure 6-2. Stress in the Crack Opening Direction, Sy, Detail

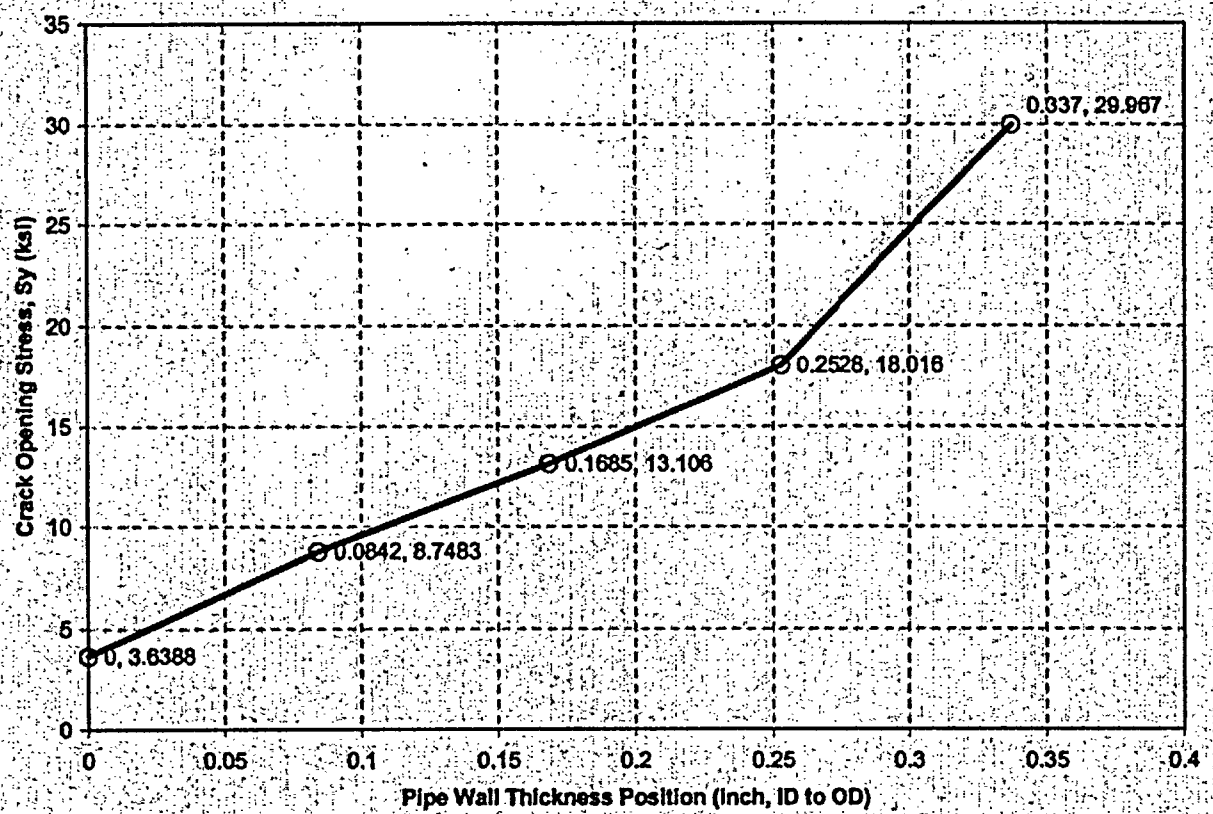

Figure 6-3. Pipe Wall Through-Thickness Stress Profile

7.0 REFERENCES

1. MPR Calculation Attach 16 to C-0142, "Natural Frequency of Loop 'B' Port," Revision 1.

2. The finite element model was developed and analyzed with the ANSYS Finite Element Analysis program Version 8.1. The analysis was performed on a Sun 280R server running the Solaris 8 operating system. The ANSYS installation verification is documented in QA-81-1.

3. Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants" October, 1973.

4. Computer output files 1108-0502-ebb-2-1 and 1108-0502-ebb-2-2.