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April 15, 1983

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Docket No. 50-275
Diablo Canyon Unit 1
License No. DPR-76

Gentlemen:

Enclosed please find Interim Technical Report No. 43 on Heat Exchangers issued by Robert L. Cloud Associates for the Independent Design Verification Program, (P105-4-839-043).

Yours truly,

Edward Denison

Edward Denison

Enclosure

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Robert L. Cloud and Associates, Inc.

RLCA

Interim Technical Report

DIABLO CANYON UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM
-HEAT EXCHANGERS-
ITR #43
REVISION 0

Docket No. 50-275
License No. DPR-76

4/14/83
Project Engineer/Date
Technical Review

Edward Denison 4/14/83
Project Manager/Date
Approved P 105-4-839-043

PDR
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TELEDYNE ENGINEERING SERVICES

PROGRAM MANAGER'S PREFACE

DIABLO CANYON NUCLEAR POWER PLANT - UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT

HEAT EXCHANGERS

This is the forty-third of a series of Interim Technical Reports prepared by the DCNPP-IDVP for the purpose of providing a conclusion of the program.

This report provides the analytical results and conclusions of the IDVP with respect to the initial sample for heat exchangers. The initial sample consists of the Component Cooling Water Heat Exchanger (CCWHX) as it is the only heat exchanger which was analyzed for Hosgri by PG&E or its seismic service related contractors. All EOI files initiated for the CCWHX have been closed.

As IDVP Program Manager, Teledyne Engineering Services has approved this ITR-43, including the analytical evaluation and conclusions presented. The methodology followed by TES in performing this review and evaluation is described in Appendix D to this report.

ITR Reviewed and Approved
IDVP Program Manager
Teledyne Engineering Services

R. Wray

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Assistant Project Manager

HEAT EXCHANGERS

Contents

List of Tables

List of Figures

1.0 INTRODUCTION

Purpose and Scope

This interim technical report summarizes the verification analysis of the initial sample of heat exchangers at Diablo Canyon Nuclear Power Plant, Unit 1 (DCNPP-1). The initial sample consists of the component cooling water heat exchanger, as it is the only heat exchanger required for Hosgri qualification that was analyzed by PGandE and/or its seismic service-related contractors.

This report is one of many interim technical reports of the Independent Design Verification Program (IDVP). Interim technical reports include references, sample definitions and descriptions, methodology, a listing of Error and Open Items, an examination of trends and concerns, and a conclusion (Reference 1). This report presents results and conclusions of the component cooling water heat exchanger verification analysis and a review of the design analysis. It also serves as a vehicle for NRC review and will be referenced in the IDVP Phase I Final Report.

Summary

Robert L. Cloud and Associates (RLCA) performed a verification analysis for the component cooling water heat exchanger at DCNPP-1. Results of the verification analysis show all loads and stresses to be below the allowables. Discrepancies in the design analysis have been noted. No additional verification is required because the component cooling water heat exchanger is the only heat exchanger required for Hosgri qualification that was analyzed by PGandE and/or its seismic service-related contractors.

Background

On September 28, 1981 PGandE reported that a diagram error had been found in a portion of the seismic qualification of the Diablo Canyon Nuclear Power Plant Unit 1 (DCNPP-1). This error resulted in an incorrect application of the seismic floor response spectra for sections of the annulus of the Unit 1 containment building. The error originated when PGandE transmitted a sketch of Unit 2 to a seismic service-related contractor. This sketch contained geometry incorrectly identified as Unit 1 geometry.

As a result of this error, a seismic reverification program was established to determine if the seismic qualification of the plant was adequate for the postulated Hosgri 7.5M earthquake. This program was presented orally to the NRC in a meeting in Bethesda, Maryland on October 9, 1981.

Robert L. Cloud and Associates (RLCA) presented a preliminary report on the seismic reverification program to the NRC on November 12, 1981 (Reference 2). This report dealt with an examination of the interface between URS/Blume and PGandE.

The NRC commissioners met during the next week to review the preliminary report and overall situation. On November 19, 1981 an Order Suspending License CLI-81-30 was issued which suspended the Diablo Canyon license to load fuel and conduct low power tests at up to 5% of rated power at DCNPP-1. This suspending order also specified that an independent design verification program be conducted to ensure that the plant met the licensing criteria.

PGandE retained Robert L. Cloud and Associates as program manager to develop and implement a program that would address the concerns cited in the Order Suspending License CLI-81-30. This program would provide for the independent verification of those buildings, equipment and components which had already been evaluated by PGandE for the Hosgri 7.5M earthquake. The Phase I plan for this program was transmitted to the NRC staff in December 1981 and discussed with the NRC staff in February 1982. Phase I specifically deals with PGandE internal activities and seismic service-related contracts prior to June 1978.

In March 1982, the NRC approved Teledyne Engineering Services as program manager to replace RLCA. However, RLCA continued to perform the independent review of seismic, structural and mechanical aspects of Phase I.

The NRC approved the Independent Design Verification Program Phase I Engineering Program Plan on April 27, 1982 (Reference 3). This plan requires that a sample of piping, equipment, structures and components be selected for independent verification. The results of these analyses are to be compared to the design analysis results. If the acceptance criteria are exceeded, an Open Item Report is to be filed. Interim technical reports are to be issued to explain the progress and conclusions of different segments of the technical work.

2.0 IDVP LICENSING CRITERIA

The IDVP used the Diablo Canyon Nuclear Power Plant Unit 1 licensing criteria to analyze the component cooling water heat exchanger (see Appendix B). This criteria is contained in the FSAR (Reference 4) and the Hosgri Report (Reference 5).

Allowable criteria are those defined in Table 7-1 and 7-2 of the Hosgri Report (Reference 5). Allowable criteria for concrete expansion anchors have been taken from PGandE Engineering Standard Drawing 054162, Revision 3, "Allowable Loads for Concrete Expansion Anchors for Seismic and Static Loading," (Reference 6).

Industry standards used for the verification of the heat exchanger sample were the ASME Boiler and Pressure Vessel Code (Reference 7) and the American Concrete Institute Code (Reference 8).

Loading combinations and structural criteria from the Hosgri Report are also included in Attachment 1 of the IDVP Phase 1 Engineering Program Plan (Reference 3).

3.0 VERIFICATION ANALYSIS FOR THE COMPONENT COOLING WATER HEAT EXCHANGER

The component cooling water heat exchanger is a shell and tube type heat exchanger used to transfer heat between fluid systems. It consists of rows of tubes encased by a shell. Sea water passes through these tubes while treated plant water flows around them within the shell. Two identical heat exchangers (1-1 and 1-2) are located in the Unit 1 portion of the turbine building at elevation 85 feet.

The heat exchanger is approximately 59 feet long. It is supported by two saddle supports which are anchored to concrete pedestals on the floor slab. The shell has an outer diameter of 71-1/4 inches, is 1/2 inch thick, and has a corrosion allowable of 1/16 inch thickness specified by the manufacturer. The total weight of the heat exchanger and the contained water is 184,000 pounds. Maximum specified fluid operating conditions at the inlet are 200 degrees Fahrenheit and 150 psi.

Plant water enters and exits through two 30 inch nozzles located on top of the shell just outboard from each saddle support location. Sea water enters and exits through two 24 inch nozzles at opposite ends of the shell bottom. The sea water inlet and discharge pipes are routed through the floor slab and connected to heat exchanger nozzles through flexible couplings. The plant water inlet nozzle enters the heat exchanger through a reinforcing ring running circumferentially around the heat exchanger shell, while the outlet nozzle attaches directly to the shell.

Figure 1 shows the general configuration of the component cooling water heat exchanger.

There are two saddle supports for each heat exchanger. These are welded fabricated plate and shell structures with reinforcing stiffener plates. A doubler plate is welded between the saddle support plate structure and the heat exchanger shell. Eight 1 inch and three 1-1/2 inch anchor bolts secure each saddle support to the floor slab, as shown in Figure 2.

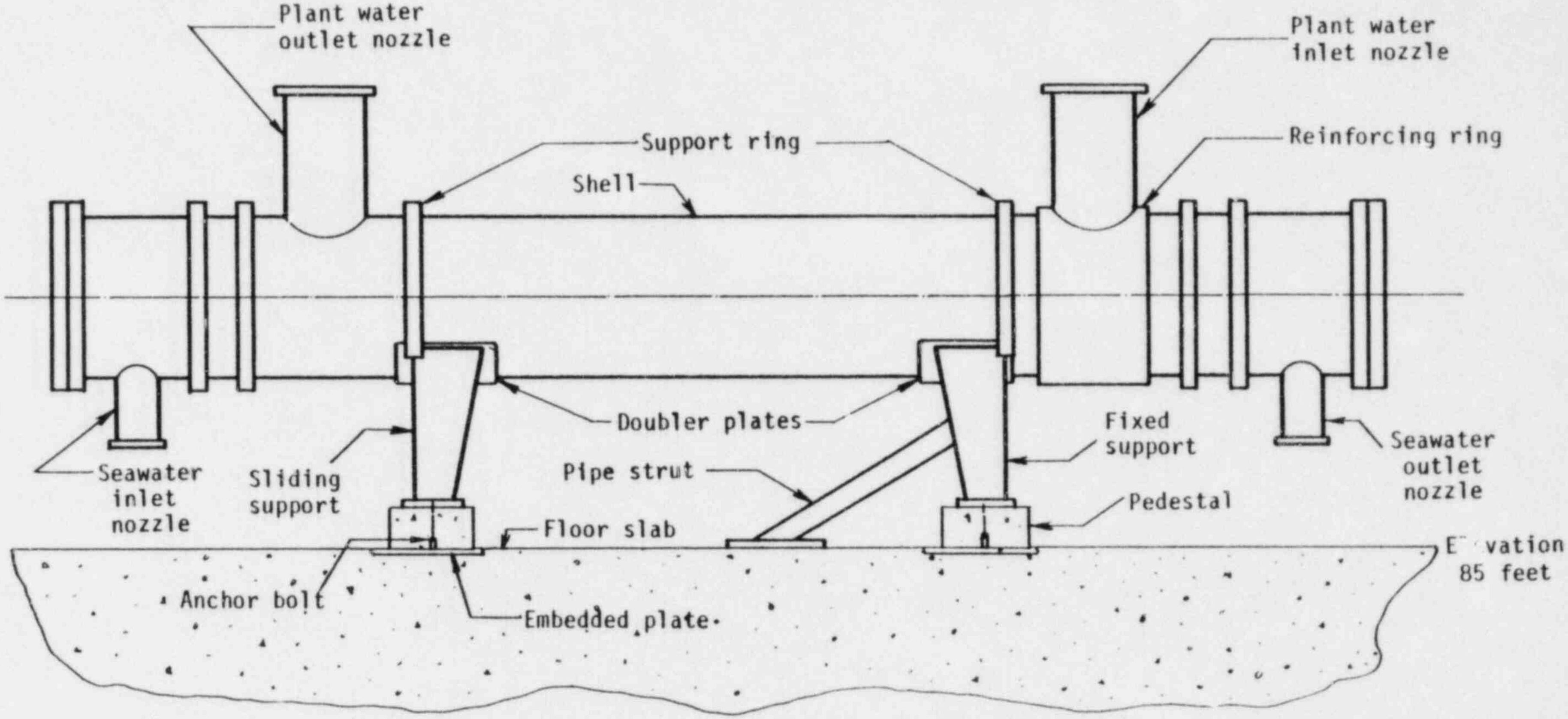

Figure 1

General Configuration of Component Cooling Water Heat Exchanger

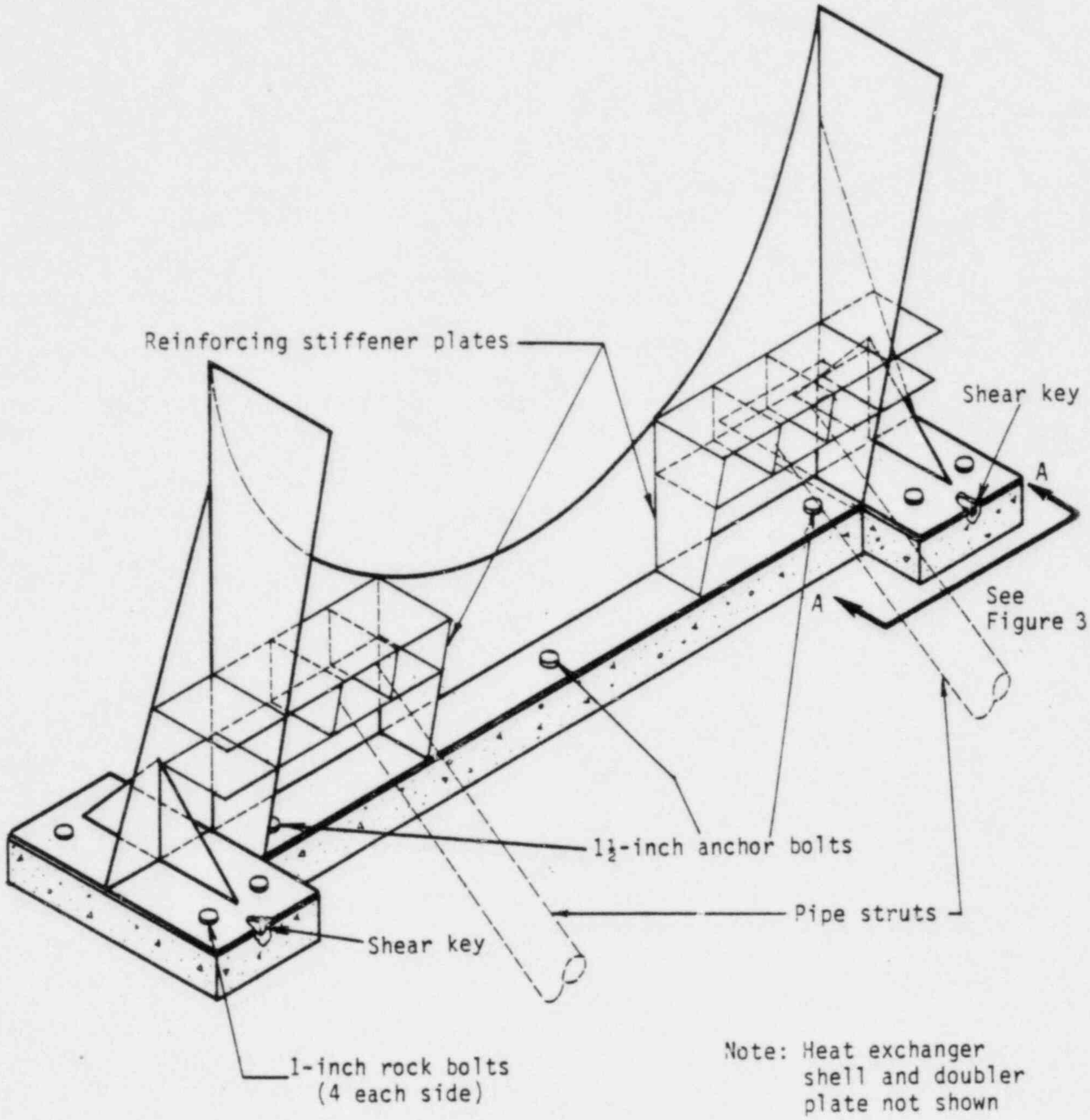

Figure 2

Fixed Saddle Support
Component Cooling Water Heat Exchanger

The saddle support at the fixed (North) end of the heat exchanger has two pipe struts extending from the floor to a point midway up on the saddle. These pipes are welded to a steel base plate. Eight 1-1/4 inch concrete expansion anchors attach the steel base plate to the floor slab. Figure 3 shows the details of the fixed saddle support end.

At the fixed saddle support, three 1-1/2 inch A307 steel anchor bolts are welded to a steel plate embedded in the floor slab. These bolts are surrounded by a concrete pedestal which extends up to elevation 85 feet-9 inches (including grout). Williams Hollow Core Rock Bolts, 1 inch in diameter, are installed into the floor slab.

Opposite from the fixed support, there is a sliding saddle support with slotted bolt holes. These allow for thermal expansion of the heat exchanger and sliding of the support in the longitudinal (North-South) direction. Figure 4 shows the general configuration of the sliding saddle supports.

To resist shearing forces, each of the saddle supports on heat exchanger 1-2 has steel plates (shear keys) welded to the underside of the base plate and embedded in the concrete pedestal. The fixed-end support has two shear keys to resist shear forces in the lateral direction, while a third shear key is located at the pipe strut base plate to resist longitudinal shear forces (Figure 5). The sliding support has two shear keys oriented to resist lateral shearing forces.

At the sliding end and at the pipe strut, heat exchanger 1-1 has the identical shear key arrangement as heat exchanger 1-2. Lateral shear forces at the fixed support of 1-1, however, are resisted by steel tee sections butting against the concrete pedestal.

The saddle supports are constructed from A-36 steel. The pipe struts are A-53 Grade B steel, and the heat exchanger shell material is SA-515 Grade 70 steel.

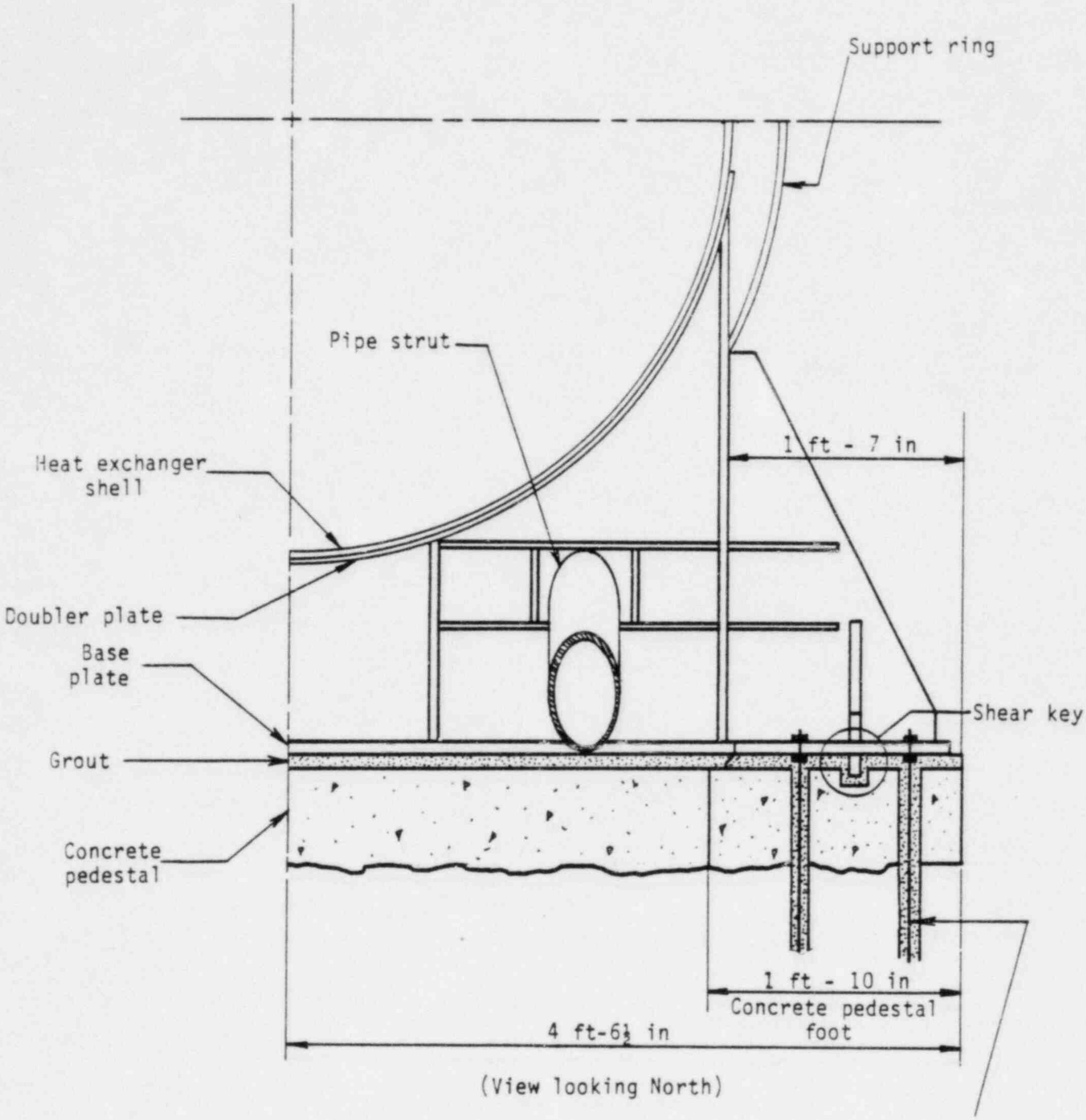

Figure 3

Details of Fixed Saddle Support
Component Cooling Water Heat Exchanger

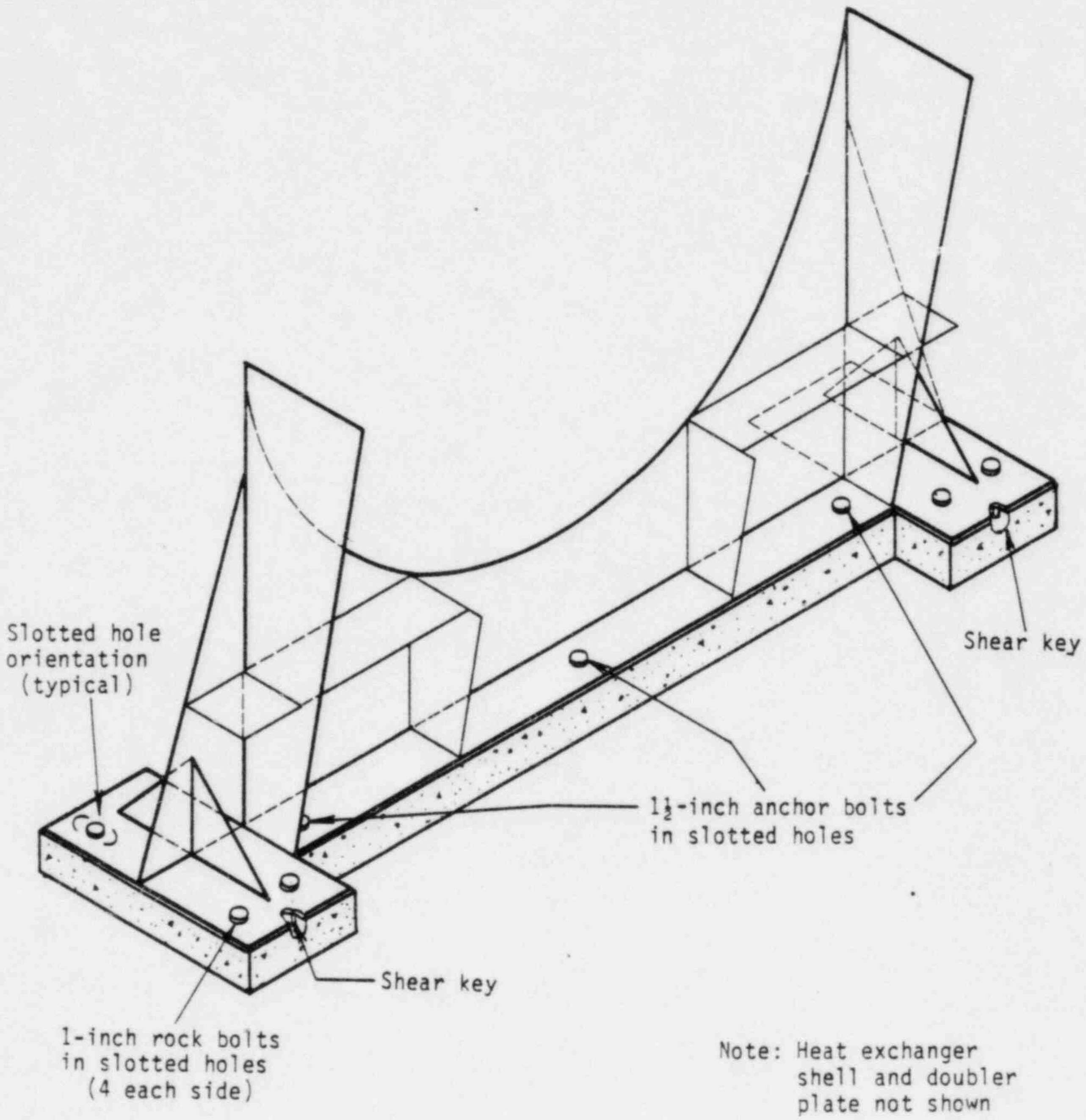

Figure 4

Sliding Saddle Support
Component Cooling Water Heat Exchanger

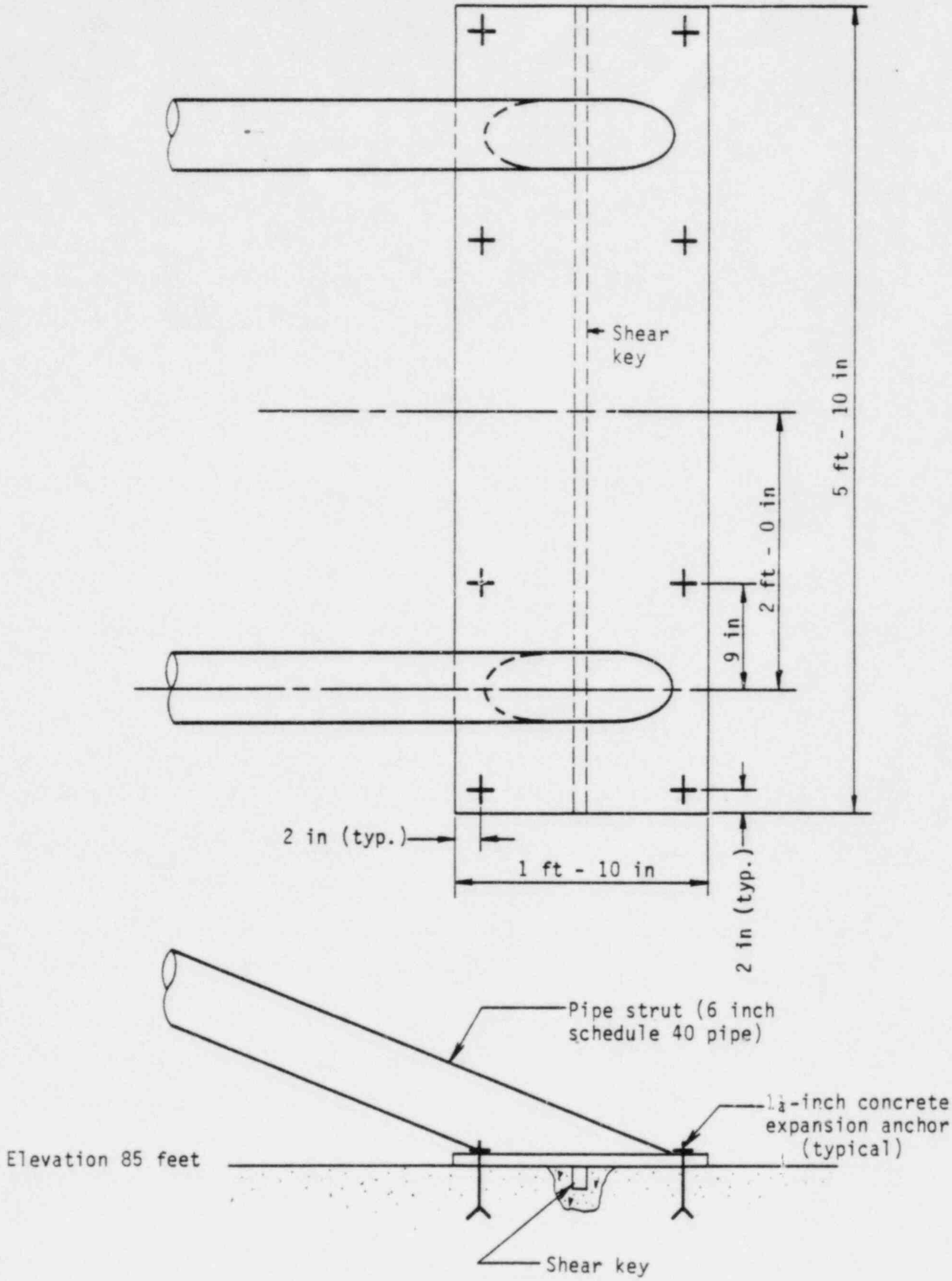

Figure 5

Details of Pipe Strut
Component Cooling Water Heat Exchanger

3.1 HEAT EXCHANGER SHELL AND SUPPORTS

After the IDVP field verified the dimensions and configuration, a STARDYNE computer model was developed.

The model consisted of a detailed representation of the saddle supports and the adjacent heat exchanger shell section as well as a simplified representation of the remaining portion of the shell. Welded stiffener plates and gussets at the supports were modeled in detail using quadrilateral and triangular plate elements. Support plate element thicknesses were specified so as to correspond to actual thicknesses. Figure 6 shows the general configuration of the STARDYNE Model.

Also modeled with quadrilateral plate elements was a 47 inch length of heat exchanger shell on both sides of each saddle support. This length was greater than the characteristic length required to isolate the remainder of the shell from local discontinuities and flexibilities at the saddle-shell interface (Reference 9).

All elements in the shell were proportioned such that the weight per unit length of the detailed model was equivalent to the weight per unit length of the total heat exchanger filled with water.

For the plate elements representing the shell, the thickness of each element corresponded to the actual thickness at the location modeled minus 1/16 inch allowed for internal corrosion. Thus, the thickness of the plate elements at the saddle-shell junction was increased to equal the total thickness of the shell and attached doubler plate at that location.

At the support location, a steel support ring runs circumferentially around the heat exchanger shell. This ring was modeled as a series of beam elements running between the appropriate plate node points as shown in Figure 7.

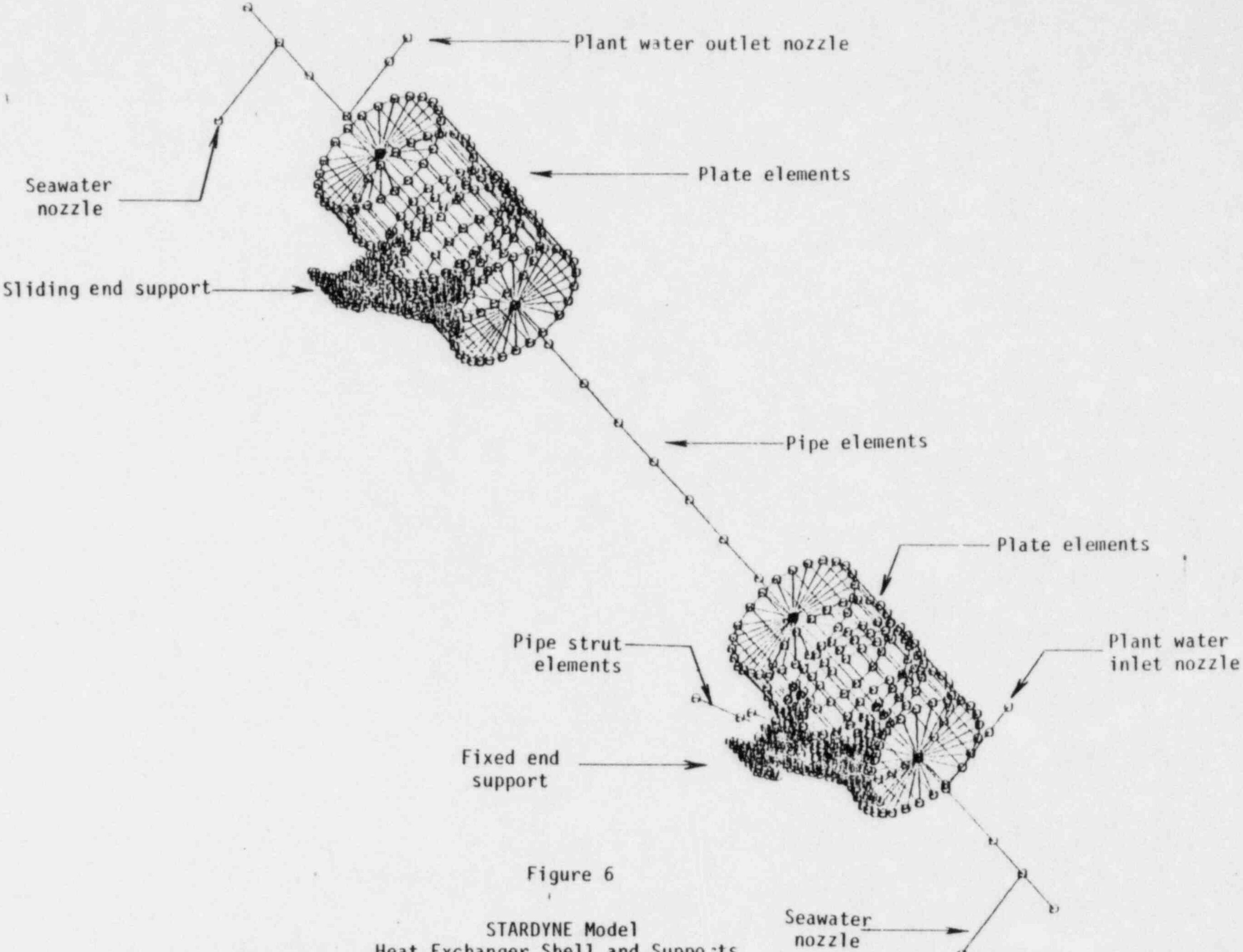

Figure 6

STARDYNE Model
Heat Exchanger Shell and Suppo·ts

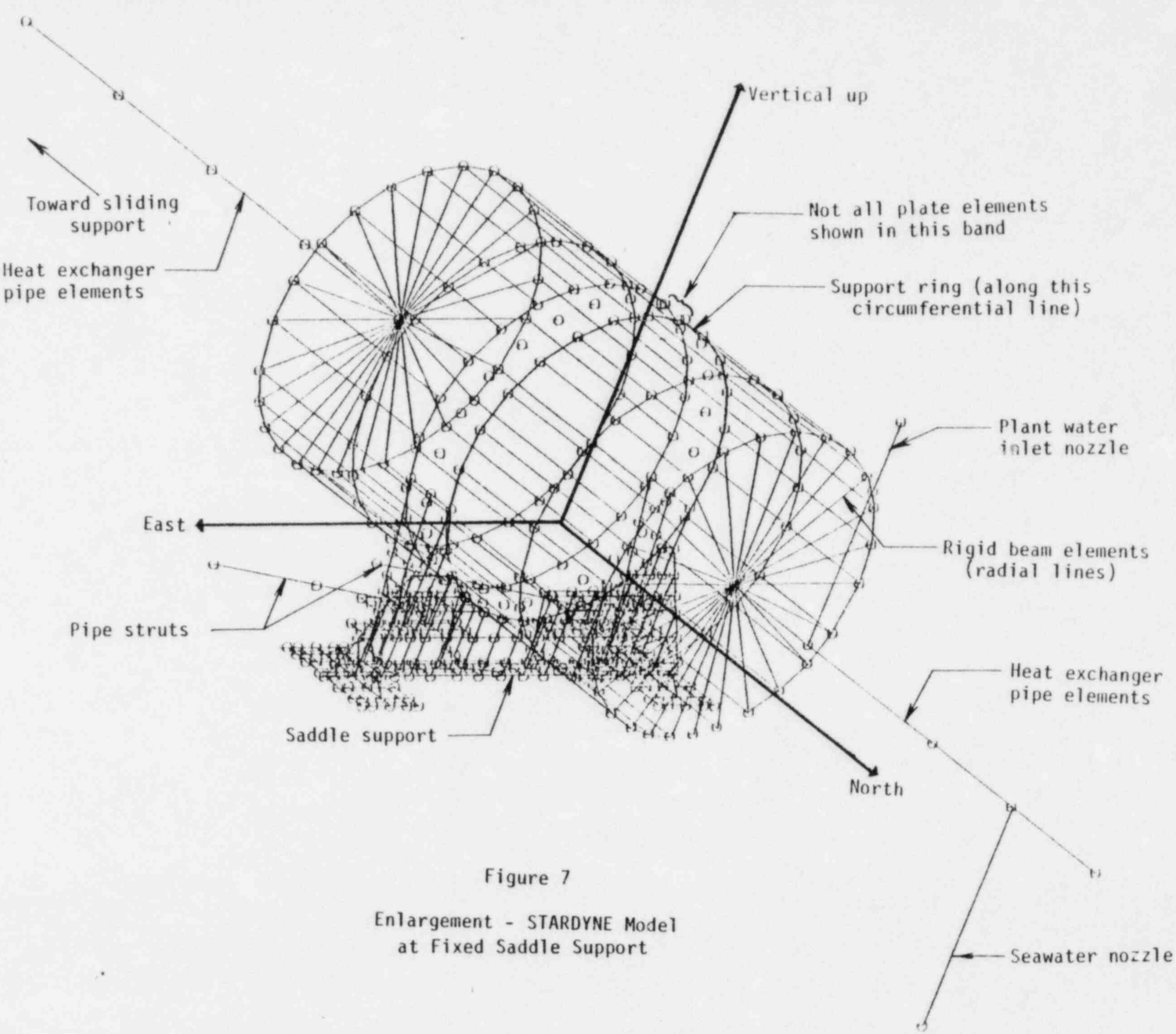

Figure 7

Enlargement - STARDYNE Model at Fixed Saddle Support

The remainder of the shell structure was modeled using pipe elements with a uniform wall thickness and diameter corresponding to the actual heat exchanger shell (minus the corrosion allowable). These elements were joined to the plates by rigid beam elements running radially from the pipe node point to each of the plate node points (see Figure 7).

The locations of the plate-pipe interfaces were sufficiently removed from the key saddle support area so that local discontinuity effects were not introduced into the STARDYNE results. Therefore, the effect of rigid beam elements on the overall structural behavior was insignificant.

Heat exchanger nozzles were located along the pipe element portion of the model. A rigid beam element represented the connection between the pipe elements located along the center line of the heat exchanger and the nozzle location. The actual nozzle was modeled with a pipe element.

3.1.1 Boundary Conditions for Heat Exchanger Shell and Supports

To model the boundary of the heat exchanger at the point where it is attached to the piping, the IDVP considered both sea water and plant water nozzles as free ends for the following reasons. The seawater nozzles are attached to pipe lines through flexible couplings. Although the plant water nozzles are attached to piping, the effect of the attached piping was accounted for by nozzle loads, which were input separately as part of the model loading.

For the fixed support, the base plate was fixed only at anchor bolt points. This was also true of the sliding end support, with the exception that the restraint in the longitudinal direction was released at each of the anchor bolt points. For both the fixed and sliding supports, downward load was distributed across the full contact area between the base plate and the pedestal rather than being concentrated at discrete points representing the anchor bolts.

The ends of the pipe struts were considered fixed to the ground.

3.1.2 Loading Conditions for Heat Exchanger Shell and Supports

The component cooling water heat exchanger shell and support model was analyzed using the criteria described in Section 2.0.

Natural frequencies and modeshapes were determined using the Lanczos modal extraction option in STARDYNE (Reference 9). Natural frequencies were found to exist in the flexible range (< 33 hertz). As a result, seismic loads were computed by a response spectrum modal superposition method.

Separate loading cases were applied to the STARDYNE model to determine loads and stresses due to seismic, piping nozzle and deadweight loads. Internal pressure stresses, determined by hand calculations, were combined with the STARDYNE computer results.

Because the heat exchanger was found to be flexible, Hosgri response spectra at 4% damping were used as seismic input (Reference 5). Vertical response spectra were enveloped from Figures 3-4 and 3-5 in the Hosgri report, while horizontal response spectra were enveloped from Figures 4-3 and 4-6 (Reference 5). The figures were enveloped only over the range of accelerations from the lowest natural frequency to the zero period acceleration.

Seismic response spectra were applied to the model in combinations of: simultaneous North - South horizontal and vertical loading; and simultaneous East - West and vertical loading.

Equipment seismic nozzle loads (Reference 10) were applied as static forces at the nozzle-to-pipe interface in the form of absolute static loads. Deadweight was accounted for by applying a 1 g downward acceleration to the heat exchanger model.

To determine maximum loading at key areas, loads from deadweight, internal pressure, and piping nozzle loads were summed absolutely with the highest set of results of two seismic loading combinations.

3.1.3 Loads and Stresses for Heat Exchanger Shell and Supports

The STARDYNE computer analysis calculated loads and stresses from the model for key areas (Reference 9).

The detailed model of the shell and supports permitted principal stresses to be obtained directly from STARDYNE results. Maximum stresses for beam, pipe and plate elements were compared to the allowables.

Each of the anchor bolt locations in the STARDYNE model were modeled as fixed points, (except for the longitudinal restraints released at the sliding support). This permitted reaction forces at each bolt location to be calculated. Maximum loads were obtained for the 1-1/2 inch anchor bolts, 1 inch rock bolts and 1-1/4 inch expansion anchors. These loads were compared to allowables. Maximum stresses were also evaluated for the concrete in which the 1 inch rock bolts are embedded.

For all bolts, reaction loads in the shear key active direction were considered to be resisted by the shear keys.

For the evaluation of the 1-1/4 inch expansion anchors at the pipe strut end, all forces and moments were considered with the exception of the longitudinal force to be resisted by the shear key. Maximum pipe strut anchor reactions were used.

Each group of four expansion anchor bolts around the individual pipe strut end was considered to act independently. Net loads from the group were evenly divided between bolts to permit evaluation of a single bolt.

The shear due to out-of-plane moment was resolved and added to the pure lateral shear to determine net shearing force on each bolt. Uplift due to in-plane moments was calculated and added to the pure uplift. Uplift and shear forces were combined through an interaction formula and compared to the allowable (Reference 6).

The 1 and 1-1/2 inch anchor bolts were evaluated for uplift only, since the shear keys resist lateral loads at the support. Longitudinal shear loads at the bolts were assigned to the shear key located at the pipe strut base plate.

Loads on the lateral shear keys at each support were determined by summing lateral reaction forces at all anchor bolt location points for that support. The shear key was assumed to resist this load.

For both the lateral and longitudinal shear keys, fillet weld shear stresses and concrete bearing stress were calculated and compared to the allowable.

Shear stress at the key fillet welds in the support structure was evaluated. Net shearing force and bending moment across the gross weld cross-section was determined from STARDYNE results. Maximum fillet weld shear stresses were calculated at the saddle support base plate and gussets, and then compared to the allowable. Shear stress in the pipe strut to base plate fillet weld was similarly calculated for the largest loading and compared to the allowable.

Pipe struts were evaluated for combined axial compression and local moment loads using STARDYNE results. A limit analysis procedure was used to determine the adequacy of the pipe strut, which is essentially a short column.

The pipe strut material was assumed by the IDVP to be A-53 Grade A steel. Subsequent information provided by the DCP showed the material to be A-53 Grade B steel. Therefore, the IDVP assumption gave conservative results because the actual Grade B steel is of higher strength than the assumed Grade A steel.

3.1.4 Results of Verification Analysis

The IDVP computed stresses at key areas and compared them to the allowable stresses as defined by the licensing criteria. The results are given in Table 1 and show that all the stresses from the verification analysis are below the allowables.

Bolts-Uplift	Computed	Allowable
1-1/2 inch anchor bolts	50,990 lb	57,000 lb
1 inch rock bolts	11,610 lb	37,000 lb
1-1/4 inch expansion anchors*	0.87	1.0
Shear Key-Longitudinal		
Concrete bearing stress	1.94 ksi	2.31 ksi
Fillet weld shear stress	12.27 ksi	24.36 ksi
Shear Keys-Lateral		
Concrete bearing stress	1.20 ksi	2.31 ksi
Fillet weld shear stress	18.48 ksi	24.36 ksi
Heat Exchanger Shell Maximum Plate-Principal Stress		
Membrane stress	26.80 ksi	35.00 ksi
Heat Exchanger Saddle Maximum Plate-Principal Stress		
Membrane stress	26.22 ksi	29.00 ksi
Saddle Support Fillet Welds		
Maximum shear stress	23.24 ksi	24.36 ksi
Pipe Strut to Base Plate Fillet Weld		
Maximum shear stress	15.03 ksi	20.16 ksi
Rock Bolt Concrete Load (uplift)	148,000 lb	402,000 lb
Pipe Strut Axial Compression and Bending		
interaction ratios **	0.959	1.0
	1.166	1.5

* combined shear/tension ratio
** must meet both allowables

Table 1
Verification Analysis - Stresses
Heat Exchanger Shell and Supports

3.2 HEAT EXCHANGER NOZZLES

Because the IDVP model discussed in Section 3.1 represents only the heat exchanger shell and supports, a second STARDYNE model was developed to include the effect of the attached piping on the nozzle loads. This model permitted the calculation of nozzle loads arising from the attached piping constraint during seismic inertial motion (Reference 11). IDVP considerations for this model were:

1. Dynamic characteristics of the overall heat exchanger structure had to be adequately represented.

2. The stiffness contribution of the attached piping had to be modeled.

To represent the overall dynamic characteristics, the IDVP modeled a simplified version of the heat exchanger and supports model described in Section 3.1. Figure 8 shows this simplified model. The saddle supports were modeled using plate and beam elements (see Figure 9). Local plate flexibilities in the support regions were modeled in less detail than in the first STARDYNE model.

The shell was modeled from pipe elements alone. The base of the saddle support including the anchor bolts was represented as rigid beam elements and springs. Springs representing the anchor bolts accounted for any rocking behavior of the support.

The IDVP verified the accuracy of the second dynamic model by comparing frequency and mode shape results with those of the first model.

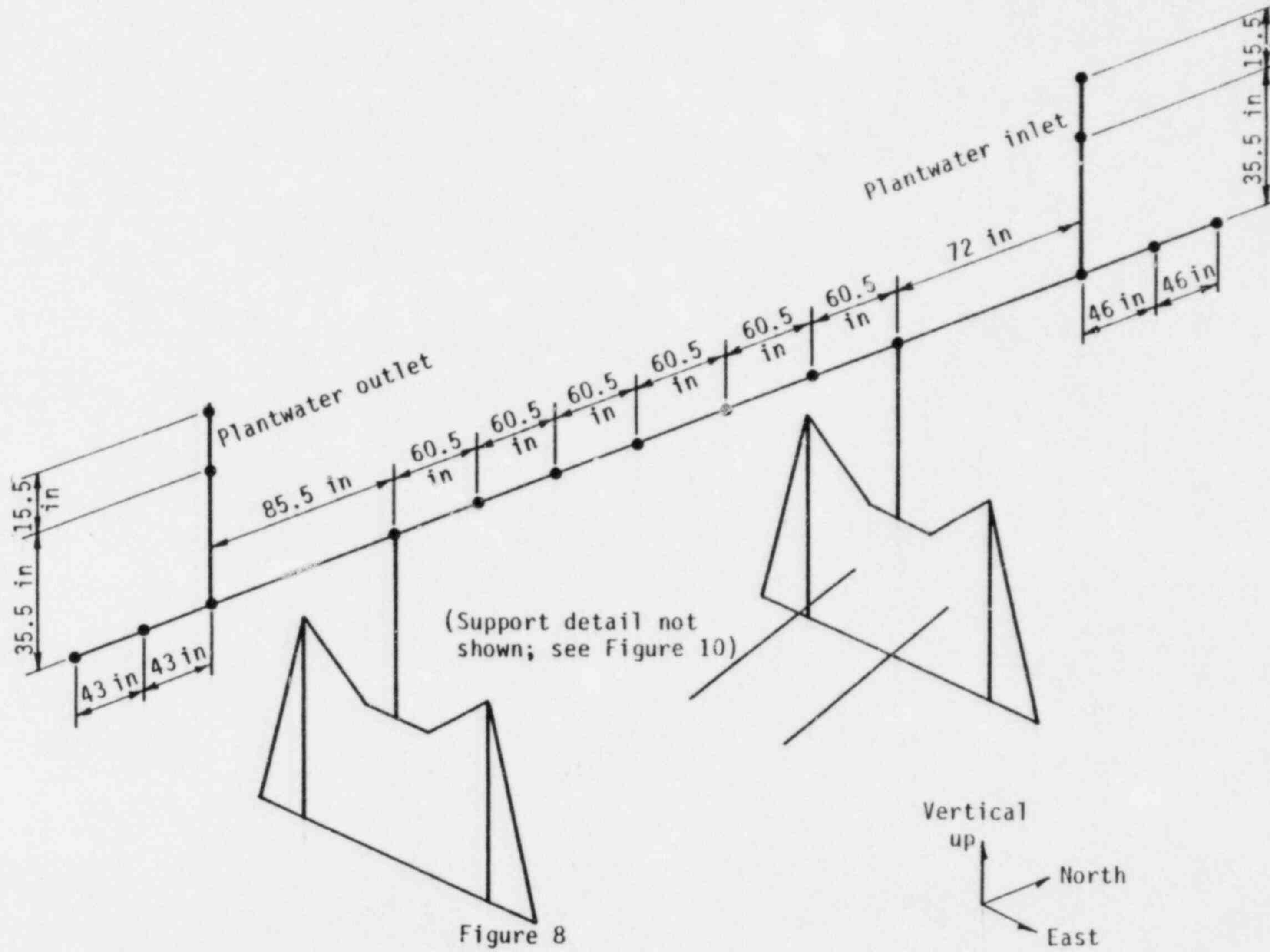

Figure 8

STARDYNE Model
Simplified Heat Exchanger with Attached Piping

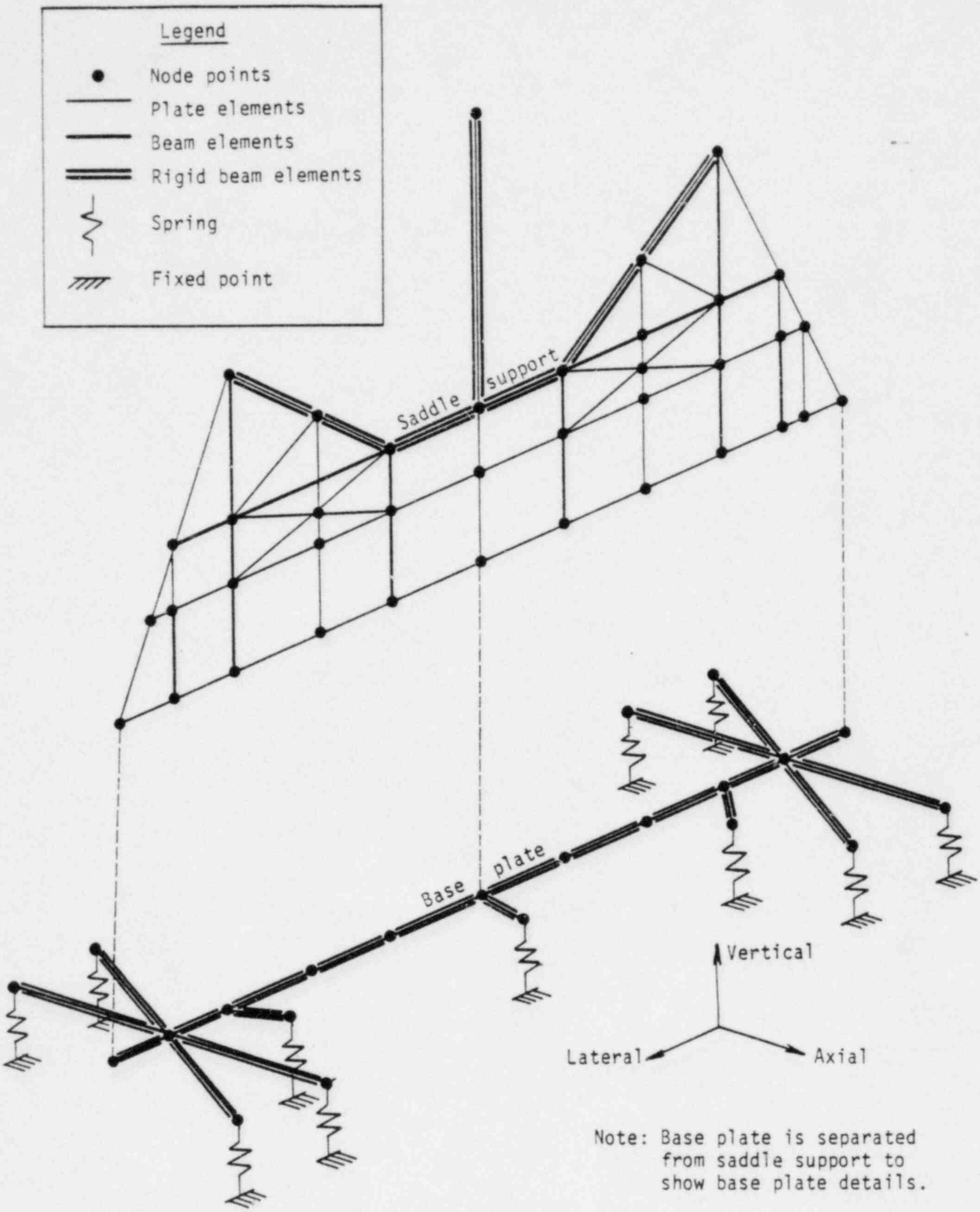

Figure 9

STARDYNE Model
Simplified Heat Exchanger with Attached Piping
Showing Base Plate and Saddle Supports

To model stiffness contributed by the attached piping, the IDVP included a portion of the attached piping and supports as shown in the isometric diagram in Figure 10. In contrast to the first model, both heat exchangers were included. This was necessary because the attached pipe lines at each heat exchanger are connected.

Because the model was used to determine constraint forces on the nozzles, the IDVP considered only stiffness effects. Rigid and snubber pipe supports were included. The effect of pipe mass and its contents was accounted for by using PGandE piping nozzle loads (see Section 3.2.2).

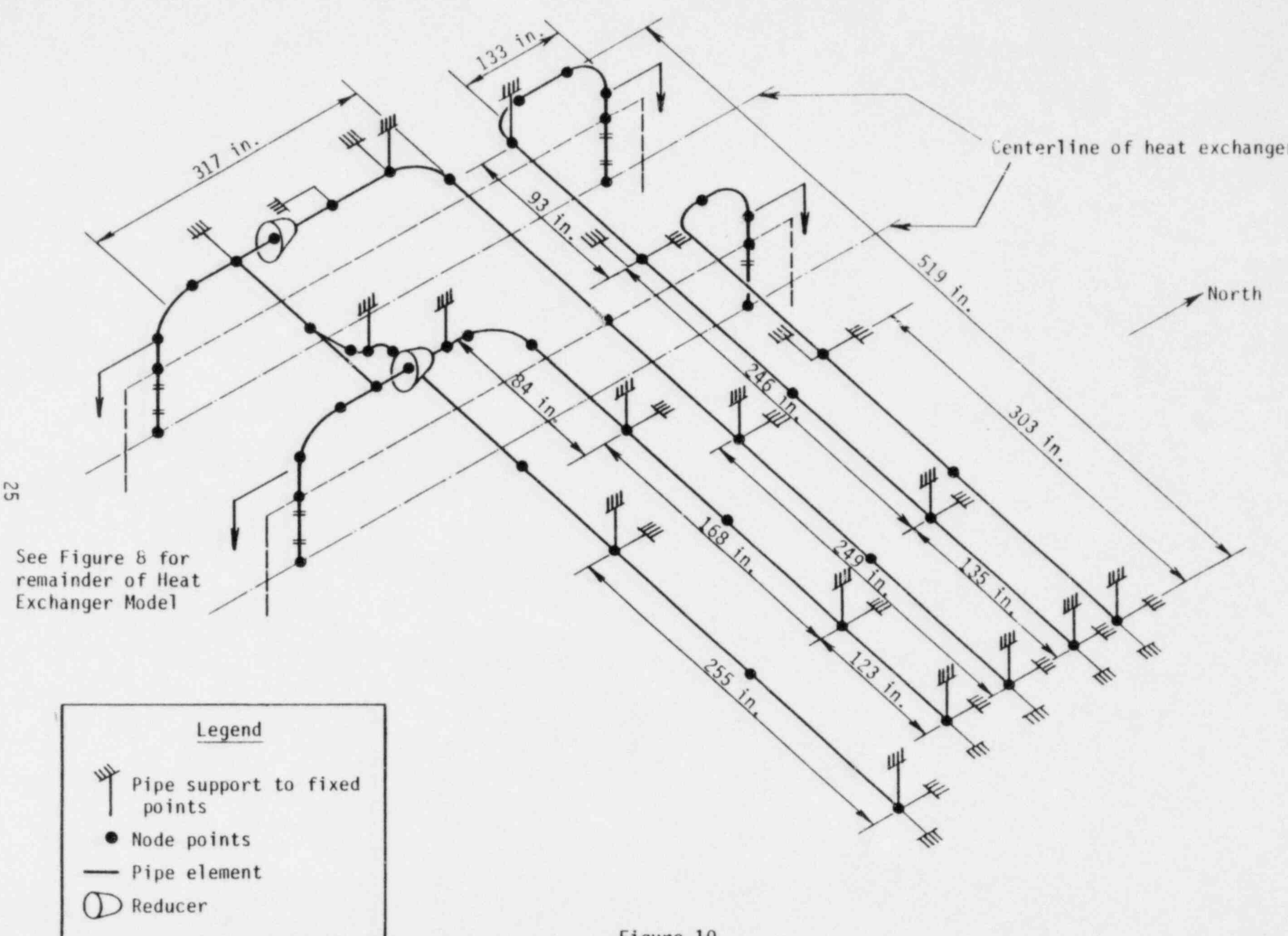

Figure 10

Isometric Drawing of Piping and Supports for Component Cooling Water Heat Exchanger

3.2.1 Boundary Conditions for Heat Exchanger Nozzles

For the second model, the IDVP considered the sea water nozzles as free ends because they are attached to pipe lines through flexible couplings (Reference 11).

For the plant water nozzles, the component boundaries were extended to include part of the attached piping and associated supports (see Figure 10). Each pipe support was modeled as a point of restraint on the pipe. The direction of restraint on the pipe corresponded to each pipe support's specified line of action.

The base plate was modeled as a series of rigid beam elements extending out to the anchor bolt locations to represent the relative stiffness of the base plate with gussets (see Figure 9). A length of rigid beam elements represented the line of contact between the support. The pedestal was assumed to be fixed.

The anchor bolts were modeled as springs between base plate rigid elements and fixed points. The stiffness of the springs was specified as the axial stiffness of a portion of bolt without bonding effect.

To verify the boundary conditions for the nozzles, frequency and mode shape results from the second model were compared to those from the detailed shell and support model. The comparison showed that the boundary conditions described above adequately model heat exchanger gross seismic motion for the nozzle analysis.

3.2.2 Loading Conditions for Heat Exchanger Nozzles

Seismic nozzle loads resulting from the constraint of attached piping were determined from the second STARDYNE model for the two heat exchangers (Reference 11). Inertial effects of the attached piping on the nozzles were already factored into PGandE's equipment nozzle loads (Reference 10).

Nozzle loads from the PGandE analysis were given in the form of unsigned static forces and moments. These loads were calculated for the end of the nozzle. To analyze the nozzle-shell junction, the IDVP transferred the loads (forces and moments) from the end of the nozzle to the mid-surface of the shell.

3.2.3 Loads and Stresses for Heat Exchanger Nozzles

Nozzle loads from seismic excitation of attached piping and heat exchanger inertial loads were applied at the nozzle-shell junction. Once inertial loads on the nozzles were determined, they were combined with PGandE attached piping nozzle loads to obtain total seismic nozzle loads. These were then used to perform a modified Bijlaard stress analysis as given in Welding Research Council (WRC) Bulletin No. 107, (Reference 12).

Stresses at the nozzle-shell junction were calculated for the two nozzles with the highest loading (Reference 11). Membrane and bending stresses in both the circumferential and longitudinal directions were calculated at eight locations of the nozzle-shell junction. Shell pressure stresses were calculated by hand and added to stresses induced by nozzle loads.

Stresses at the most highly stressed locations were combined to determine primary longitudinal and circumferential stresses.

3.2.4 Results for Heat Exchanger Nozzles

The IDVP calculated stresses at the nozzle - shell junction with the highest net loading. These primary stresses were compared to the allowables defined by the licensing criteria.

Location	Computed (ksi)	Allowable (ksi)
Heat Exchanger 1-1 Inlet Nozzle-Primary Stress Intensity	35.2	54.0

The results show that the highest primary stress is below the allowable.

4.0 DESIGN ANALYSIS METHODS FOR THE COMPONENT COOLING WATER HEAT EXCHANGER

The complete design analysis consisted of a set of separate calculations for the heat exchanger, shell, supports, foundation and nozzle-shell junction done by both PGandE and their seismic service-related contractor.

Heat Exchanger Shell

In the portion of the design analysis for the heat exchanger shell, longitudinal and circumferential stresses were calculated (Reference 13). Stresses for pressure, deadweight and seismic loading were combined. Seismic stress was calculated as a function of seismic acceleration. Combined stress was divided into allowable stress, and a maximum seismic acceleration capability was determined. Simultaneous horizontal and vertical seismic accelerations were combined by considering vertical acceleration as 2/3 that of the horizontal.

The conclusion of the design analysis was that the heat exchanger shell is capable of withstanding a seismic acceleration of 7.86 g. This result exceeds the maximum postulated Hosgri acceleration of 1.9 g.

The design calculation for the shell alone did not include the contribution of piping nozzle loads.

Heat Exchanger Supports

ANCO Inc., a seismic service-related contractor, performed a separate analysis for the overall heat exchanger and support structure for seismic loading (Reference 14). For this analysis, the heat exchanger configuration was considered without support gussets, stiffeners and pipe struts, which prior to 1978 had not been included in the original installed configuration.

The heat exchanger and support structure was analyzed for seismic loading using the computer code EASE2. No deadweight or nozzle loads were included. The ANCO, Inc. study concluded that additional support bracing was required to reduce support loads.

A modification to the heat exchanger and supports was proposed, which included five axial pipe struts and added lateral bracing. A simplified computer model of the heat exchanger including the proposed modifications was developed and analyzed, as shown in Figure 11. This analysis included the effect of the sliding support at one end.

Frequencies and mode shapes were determined from this model. A response spectra modal superposition analysis was performed to determine seismic loading at the support.

Enveloped response spectra at 4% damping were applied in all three directions simultaneously. Horizontal response spectra were applied in two horizontal directions simultaneously and the vertical response spectrum was applied simultaneously with the horizontal input. The spectra used, though preliminary spectra, were identical to Hosgri spectra (Reference 14).

The remaining design calculations were performed by PGandE rather than their seismic service-related contractor (Reference 15).

For the support pipe struts, the design analysis used support loads from the modified analysis of ANCO, Inc. Net support reactions for the five longitudinal struts in the ANCO model were summed and considered as net reactions for the actual configuration which consisted of two pipe struts.

Maximum allowable loads for the actual pipe strut configuration were calculated based on pipe longitudinal loading, uplift on the concrete expansion anchors, shear key stress, and shear key to concrete bearing stress. Allowables were then compared to computed loads for pipe strut reactions. The result showed the loads to be below allowables.

A new computer model of the heat exchanger was developed using the computer code STRUDL-II as shown in Figure 12. This model, while similar to the one used by the ANCO Inc., included the actual as-built configuration of the two axial pipe struts. Piping nozzle loads were applied and support reactions due to nozzle loads were determined.

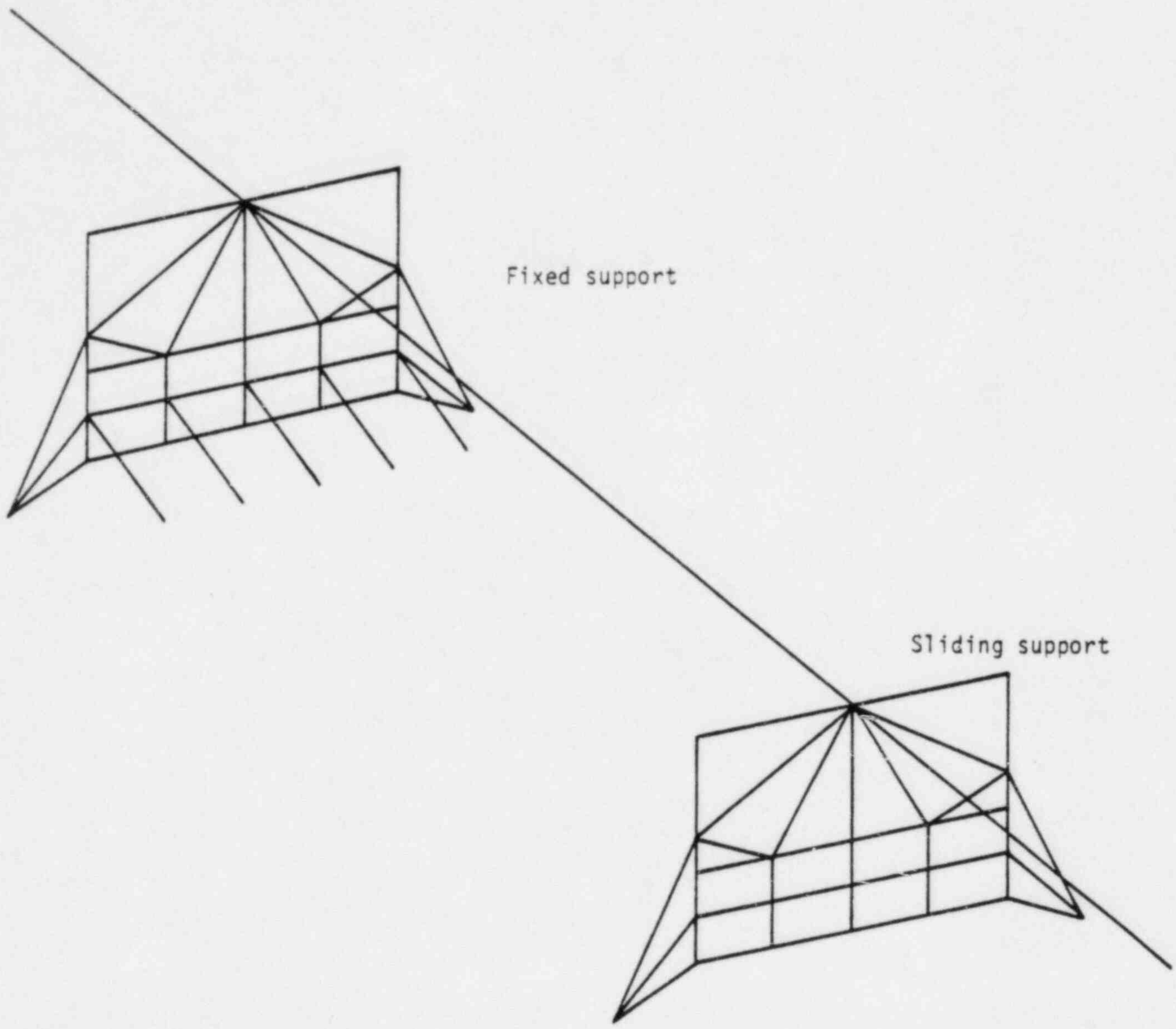

Figure 11

ANCO Design Analysis Model
Simplified Heat Exchanger with Modified Supports

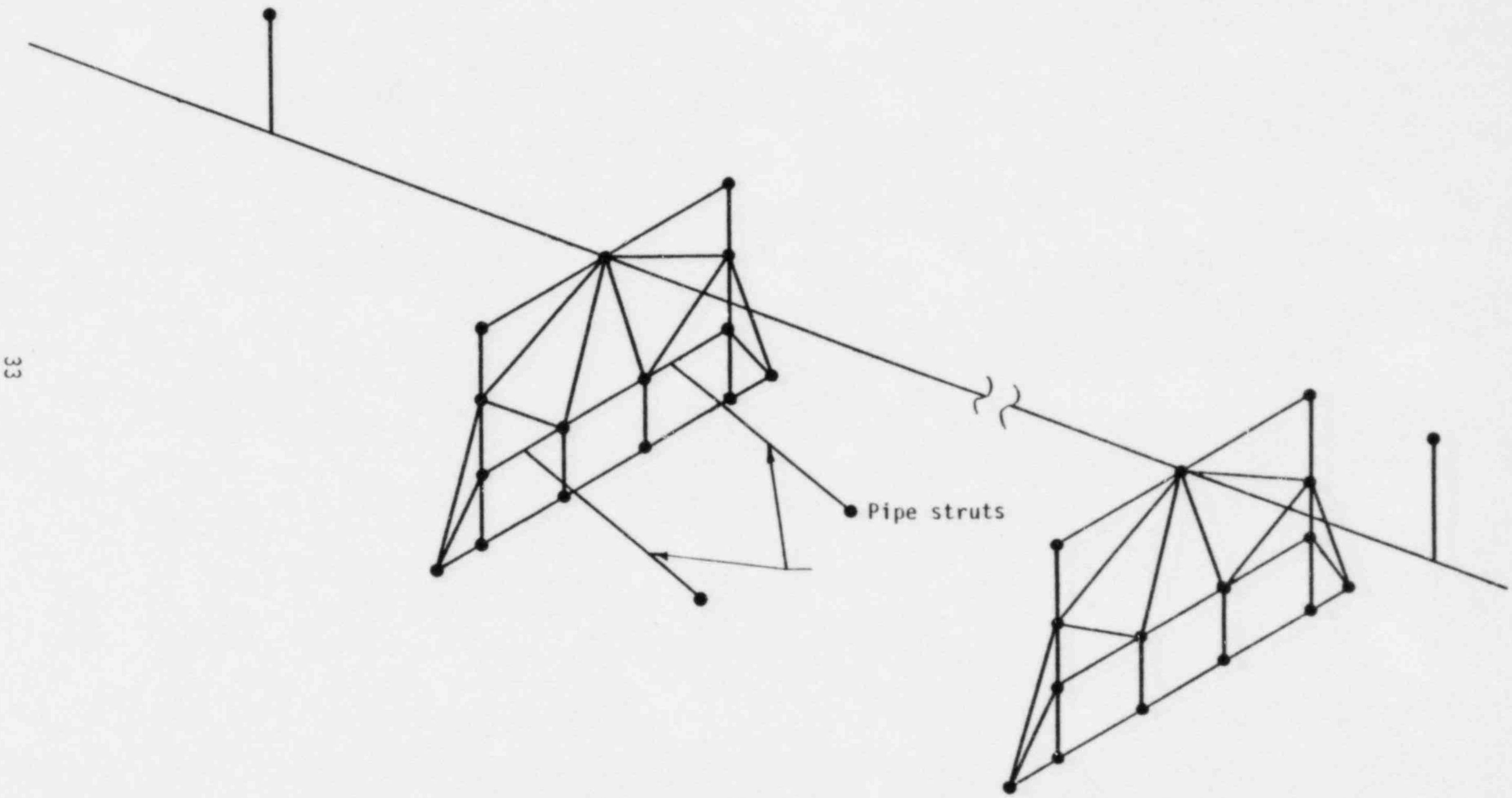

Figure 12

Design Analysis STRUDL Model
Simplified Heat Exchanger with Pipe Struts

Longitudinal shear key-concrete bearing stress due to nozzle loads was calculated and then combined with stress from heat exchanger seismic loads. Loads and stresses for pipe strut loading, concrete expansion anchors and the lateral shear key were calculated for the heat exchanger seismic loading alone. These were compared to the allowables. The comparison showed that all loads on the support were below the allowable.

The design calculation for pipe struts considered only axial loads on pipe members. End moments on the pipes were not included in their calculation.

For the 1 inch rock bolts and the lateral shear keys, the design analysis used seismic support loads from the modified seismic service-related contractor's analysis. Lateral shear key stresses and concrete bearing stress for lateral support reaction forces were calculated and compared to allowables.

Support uplift reactions were used to calculate the tensile load and required embedment depths for the rock bolts. This ensured that the shear stresses for the rebar to grout, grout to concrete, and concrete remain below allowables. These results were used to specify the installation embedment length of the rock bolts.

At the fixed end support of heat exchanger unit 1-1, tee sections were specified and designed to account for insufficient embedment depth for the lateral shear keys. The design was based on concrete bearing stress and tee and weld stress. Lateral support reaction loads were used to calculate concrete bearing stress for the tee section butting against the concrete pedestal. Stresses on the tee section welds and at the attachment point to the base plate were also calculated. Results were used to specify the size of the tee and its connections.

Heat Exchanger Nozzle-Shell Junction

In the portion of the design analysis relating to the heat exchanger nozzle-shell junction (Reference 16), stresses were calculated for the nozzle with the highest attached pipe nozzle loading. Hosgri seismic, deadweight and normal thermal nozzle loads were considered.

The inclusion of thermal loads, however, is not required because the Hosgri report requires that only those stresses produced by mechanical loads be used for the Hosgri evaluation (Reference 5). This net nozzle loading (including thermal loads), was not always the most conservative value when compared to the seismic nozzle load alone. This is because seismic nozzle loads were considered as signed (plus and minus) loads and were algebraically summed with normal thermal and deadweight loads.

The design calculation did not transfer forces at the end of the nozzle to the nozzle - shell junction. Because the attached piping nozzle loads are computed at the end of the nozzle, loads used in the design calculation for the evaluation of the nozzle-shell junction were incorrect.

All stresses were considered as primary stresses. Membrane and bending stresses were combined for the longitudinal and circumferential directions. This stress intensity was conservatively compared to the Hosgri faulted condition allowable.

For membrane stresses, the design analysis calculated local surface membrane stress by including a local discontinuity stress concentration factor (Reference 16). This calculation gave conservative results which are not required for a primary stress evaluation.

5.0 COMPARISON OF VERIFICATION AND DESIGN ANALYSES

Generally, the verification and design analyses used different approaches to analyze the heat exchanger. Whereas the verification analysis used an integrated analysis considering combined seismic, deadweight, nozzle and pressure loads to evaluate all key areas of the heat exchanger, the design analysis used separate calculations to analyze various key parts of the heat exchanger for separate loadings.

Heat Exchanger Shell

The verification analysis calculated shell stresses due to actual combined seismic, deadweight, pressure and nozzle loads, and compared these stresses to the allowables. The design analysis calculated shell longitudinal and circumferential stresses as a function of the seismic acceleration plus pressure and deadweight load. These stresses were set equal to the allowable to determine the maximum seismic capability of the shell.

Because different approaches were used in the verification and design analyses, they yielded different results which could not be directly compared. Both analyses, however, determined that the heat exchanger shell stresses were below the allowables for Hosgri loading conditions.

Heat Exchanger Supports

As described in Section 4.0, the design calculations for the heat exchanger support used loads developed from the seismic service-related contractor's model (Reference 14). This model considered a fixed support configuration with five axial pipe struts as opposed to the two pipes that are actually installed. Only seismic loads were calculated; deadweight and nozzle loads were not. Pressure load was also not included since it was irrelevant to the analysis of the support. Nozzle loads were considered only for the shear key at the end of pipe struts.

In contrast, the verification analysis developed loads and stresses for the as-built configuration and considered seismic, deadweight, nozzle and pressure loads together.

The design calculation for the pipe struts summed the total reaction loads on the five struts used in the EASE2 computer model and applied them evenly to the two actual struts. Local bending moments at the ends of the struts were not included. The verification analysis included the two pipe struts in their STARDYNE model and determined pipe axial and local bending loads directly.

The verification and design analyses evaluated shear keys using similar methods. The only difference was that the design analysis considered nozzle loads only for the pipe strut shear keys.

The design calculation for the 1-1/4 inch concrete expansion anchors evaluated only the pullout loads from summed pipe strut upward reactions. Verification analysis pullout loads included both the upward reaction force and pullout from local moment effects. In addition, the verification analysis evaluated shear loads on the 1-1/4 inch expansion anchors. These loads result from the lateral shear force acting perpendicular to the shear key line of action and local moment effects.

For the 1-inch rock bolts, the design analysis compared uplift reaction force against the manufacturer's load ratings. Required embedment depth for concrete, grout and rock bolt was calculated to develop required shear forces for calculated uplift force. Since the design analysis calculated minimum embedment depths, and the verification analysis calculated shear stresses based on the actual embedment depth, these results could not be directly compared. The results of both analyses, however, showed that all allowables were met.

The design analysis obtained uplift reactions for the four Williams Hollow Core Rock Bolts from the seismic service-related contractor's computer load results. This was in the form of a point load at the node point representing the approximate location of the rock bolt group. The verification analysis' STARDYNE model included the rock bolt locations as discrete points. Thus, the verification analysis was able to evaluate maximum individual rock bolt load.

The design analysis did not evaluate the 1-1/2 inch anchor bolts for the as-built support configuration, nor were the plate and weld stresses

in the support structure evaluated. The IDVP evaluated these and found that anchor bolt loads and plate and weld stresses were below allowables.

Heat Exchanger Nozzle-Shell Junction

The design and verification analyses for the nozzle-shell junction differed significantly in four areas of applied loading. First, the verification analysis considered the effect of additional nozzle load produced by constraint of attached piping during heat exchanger seismic inertial movement, whereas the design analysis did not.

Second, though both analyses used the same tabulated piping seismic nozzle loads, the design analysis did not transfer these loads, which were computed at the end of the nozzle, to the nozzle-shell junction. As a result of this transfer, the resulting moment is increased by as much as 51 per cent.

Third, the design analysis included thermal nozzle loads in their evaluation. The verification analysis did not include them since stress criteria (Reference 5) specify that only mechanical loads are to be considered.

Fourth, the design analysis algebraically summed thermal, deadweight and seismic nozzle loads; these last were considered as signed (plus or minus) loads. The IDVP determined that use of signed seismic loads generated from response spectra analyses is incorrect. The verification analysis summed the loads absolutely irrespective of sign.

The verification analysis compared primary stresses at the nozzle-shell junction to the allowable and found stresses to be below the allowables. The design analysis compared the sum of the primary and secondary stresses to the Hosgri allowable. IDVP results show that if nozzle loads were transferred to the nozzle-shell junction and primary stresses were conservatively combined with the secondary stresses, the combined stress would exceed the allowable used in the design analysis. As discussed previously, the design analysis did not transfer nozzle loads to the nozzle-shell junction.

6.0 EOI REPORTS

The IDVP issued three EOIs for heat exchangers. Two EOIs specifically address the component cooling water heat exchanger. Appendix A shows the EOI number, revision, date and status.

EOI 1088 was issued because the differences between the verification and design analyses exceed the acceptance criteria. The major factors contributing to the differences are listed below.

1. The as-built support configuration was not used to generate seismic loads.

2. End moments on the pipe struts were not considered in evaluating the struts.

3. Nozzle loads were not included in the evaluation of the entire support structure and shell.

4. Expansion anchor bolts were not evaluated for shear loads and the additional uplift due to pipe strut end moments.

5. The nozzle-shell junction analysis did not transfer loads from the end of the nozzle to the nozzle-shell interface.

6. Seismic nozzle loads used in the nozzle-shell analysis were considered as signed loads and algebraically summed.

7. The effect of the additional load produced by the constraint of attached piping during heat exchanger seismic inertial movement was not considered.

Items 1, 3, 5, 6 and 7 are considered to be errors; however, results of the verification analysis showed all loads and stresses to be below allowables. Therefore, EOI 1088 was resolved as a Class C error.

EOI 1099 was issued because IDVP field verification showed that stiffener plates and tee section shear restraints on heat exchanger 1-1 were not installed on heat exchanger 1-2. This discrepancy was not noted on the design drawing. However, the IDVP determined that the design analysis adequately accounted for the stiffener plates and tee section shear restraints. As a result of this EOI, the design drawing was subsequently revised to show actual configuration. Therefore, EOI 1099 was classified as a deviation.

The IDVP issued one other EOI, which did not deal specifically with the component cooling water heat exchanger. EOI 978 resulted from the RLCA "Preliminary Report, Seismic Reverification Program," dated November 12, 1981 (Reference 3).

EOI 978 noted that the vertical response spectra used in the NSSS supplier analysis of the regenerative heat exchanger was two-thirds of the filtered horizontal spectra, whereas two-thirds of the unfiltered horizontal spectra should have been used. When the IDVP reviewed the NSSS analysis using the correct response spectra, all stresses were shown to be below allowables. Therefore, EOI 978 was resolved as a Class C error.

7.0 EVALUATION

The IDVP performed a verification analysis for the component cooling water heat exchanger. IDVP results were compared to allowables and verification and design analysis methods were compared.

Results of the verification analysis show all loads and stresses for the component cooling water heat exchanger to be below allowables. The concerns that resulted in a Class C error are noted in Section 6.0. No additional verification or sampling is required. This is because the component cooling water heat exchanger is the only heat exchanger required for the Hosgri qualification that was analyzed by PGandE and/or its seismic service-related contractors.

8.0 CONCLUSION

Results of the verification analysis show that all stresses were below the allowables for the component cooling water heat exchanger. As a result of comparing the design and verification analyses, however, errors in the design analysis were noted.

The component cooling water heat exchanger is the only heat exchanger required for Hosgri qualification that was analyzed by PGandE and/or its seismic service-related contractors. Therefore, no additional verification or sampling is required.

9.0 REFERENCES

Reference No.	Title	RLCA File No.
1	DCNPP Independent Design Verification Program, Phase 1, Revision 1, July 6, 1982, (Revision 0, March 29, 1982).	
2	Preliminary Report, Seismic Reverification Program, Robert L. Cloud Associates, November 12, 1981.	
3	DCNPP Independent Design Verification Program, Program Procedure, Phase 1, Engineering Program Plan, Revision 0, March 31, 1982.	
4	Diablo Canyon Site Units 1 and 2 Final Safety Analysis Report, USAEC Docket Nos. 50-275 and 50-323.	P105-4-200-005
5	Seismic Evaluation for Postulated 7.5M Hosgri Earthquake, USNRC Docket Nos. 50-275 and 50-323.	P105-4-200-001
6	PGandE Engineering Standard, Drawing 054162, Revision 3, Concrete Expansion Anchors for Static and Seismic Loading.	P105-4-456-054
7	American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section VIII, Division 1, Section III Appendices.	
8	American Concrete Institute, ACI Standard 318-77, with 1980 Supplement, Building Code Requirements for Reinforced Concrete.	

Reference No.	Title	RLCA File No.
9	RLCA Analysis, Component Cooling Water Heat Exchanger, Revision 4.	P105-4-550-022
10	PGandE Unit 1, Class 1 Equipment Nozzle Loads, MandNE File No. 140.170, February 2, 1981.	P105-4-435-005
11	RLCA Analysis, Component Cooling Water Heat Exchanger (Nozzle-Shell Junction), Revision 1.	P105-4-550-027
12	Welding Research Council, Bulletin No. 107, Local Stresses in Spherical and Cylindrical Shells due to External Loadings, Wichman, Hopper and Mershon, March 1979 Revision.	
13	PGandE CCW Heat Exchanger Shell Stress Calculation, 2/25/77, and MandNE File 140.062, Tab G.	P105-4-435-047 P105-4-435-006
14	ANCO, Inc., Final Report, Dynamic Modeling and Seismic Analysis of the Component Cooling Water Heat Exchanger at the Diablo Canyon Nuclear Power Plant, Report No. 1122-4B.10, August, 1978, PGandE MandNE File 9.731.	P105-4-445-010
15	PGandE Analysis of CCW Heat Exchanger Anchorage, from Calculation 33T.	P105-4-435-038
16	PGandE Design Calculation for CCW HX Nozzle-Shell Junction, 12/12/80, MandNE File 140.062.	P105-4-435-021
17	Independent Design Verification Program, Program Procedure, Preparation of Open Item Reports, Error Reports, Program Resolution Reports and IDVP Completion Reports, DCNPP-IDVP-PP-003, Revision 1, 6/18/82.	

Reference No.	Title	RLCA File No.
18	PGandE Drawing, Record Number DC-663212-1-7, Outline.	P105-4-459-052
19	PGandE Record Number DC-663212-5-1 Manufacturer's Data Report.	P105-4-459-071
20	PGandE Drawing, Record Number DC-663212-7-3, Horizontal Supports.	P105-4-459-054
21	PGandE Drawing, Record Number DC-663212-8-1, Shell, Channels and Channel Cover Details.	P105-4-459-055
22	PGandE Drawing, Record Number DC-663212-11-5, Seams and Connection Details.	P105-4-459-058
23	PGandE Record Number DC-663212-45-1, Specification Sheet.	
24	PGandE Drawing Number 463676, Revision 3, Equipment Anchorage Modification.	P105-4-455-040
25	PGandE Drawing Number 438311, Change 3, Turbine Building Equipment Pads.	P105-4-459-073
26	PGandE Drawing Number 463683, Revisions 6 and 7, Equipment Anchorage Modifications, Component Cooling Water Heat Exchanger.	P105-4-459-072 P105-4-1099-006

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Appendix A

EOI Status - Heat Exchangers

(1 page)

EOI Status

Component Cooling Water Heat Exchanger

EOI File No.	Subject	Rev.	Date	By	Type	Action Required	Physical Mod.
978	Regenerative Heat Exchanger - Incorrect vertical seismic input	0	2/8/82	RLCA	PER/A	PGandE	
		1	5/10/82	RLCA	PER/C	TES	
		2	6/7/82	TES	ER/C	PGandE	No
		3	6/21/82	TES	CR	None	
1088	CCW Heat Exchanger - Difference in results, Discrepancies in design analysis methodology	0	5/14/82	RLCA	OIR	RLCA	
		1	6/18/82	RLCA	PER/A	TES	
		2	8/17/82	TES	OIR	RLCA	
		3	11/3/82	RLCA	PER/A	TES	
		4	11/19/82	TES	OIR	RLCA	
		5	2/25/83	RLCA	OIR	RLCA	
		6	2/25/83	RLCA	PER/C	TES	
		7	4/7/83	TES	ER/C	PGandE	
		8	4/15/83	TES	CR	None	No
1099	CCW Heat Exchanger - Support as-built condition differs from design condition	0	8/4/82	RLCA	OIR	RLCA	
		1	8/16/82	RLCA	PPRR/OIP	PGandE	
		2	8/20/82	TES	PRR/OIP	PGandE	
		3	11/4/82	TES	OIR	RLCA	
		4	2/16/83	RLCA	PPRR/DEV	TES	No
		5	2/25/83	TES	PRR/DEV	TES	
		6	2/25/83	TES	CR	None	

STATUS: Status is indicated by the type of classification of latest report received by PGandE:

- OIR - Open Item Report
- PPRR - Potential Program Resolution Report
- PRR - Program Resolution Report
- PER - Potential Error Report
- OIP - Open Item with future action by PGandE
- ER - Error Report
- CR - Completion Report
- CI - Closed Item
- DEV - Deviation
- A - Class A Error
- B - Class B Error
- C - Class C Error
- D - Class D Error

PHYSICAL MOD: Physical modification required to resolve the issue. Blank entry indicates that modification has not been determined.

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Appendix B

Licensing Criteria

(2 pages)

Appendix B

Licensing Criteria

Component (1,2)	Loading Combinations (3)	Criteria (6,7,8,9)	
Tanks, Heat-Exchangers, Filters, Demineralizers	Deadweight + Pressure + Seismic + Nozzle Loads	σ_m	$\leq 2.0S$
		$(\sigma_m \text{ or } \sigma_L) + \sigma_b$	$\leq 2.4S$

(1) Active : Mechanical equipment which is needed to go from normal full power operation to cold shutdown following the earthquake and which must perform mechanical motions during the course of accomplishing its design function.

(2) Inactive : Mechanical equipment which is not required to perform mechanical motions in taking the plant from normal full power operation to cold shutdown following the earthquake.

(3) Nozzle loads shall include all piping loads transmitted to the component during the Hosgri earthquake.

(4) Piping loads at piping/active-valve interfaces shall be limited such that maximum fiber stresses in the piping at the interface are less than the piping yield strength at temperature (S_y).

(5) Valves, being stronger than the attached piping and having a proven history without any gross failures of pressure boundaries, can safely transmit piping levels without compromising their pressure retaining integrity. Therefore piping integrity assures valve integrity.

(6) σ_m = general membrane stress. This stress is equal to the average stress across the solid section under consideration, excludes discontinuities and concentrations and is produced only by mechanical loads.

(7) σ_L = local membrane stress. This stress is the same as σ_m except that it includes the effect of discontinuities.

(8) σ_b = bending stress. This stress is equal to the linear varying portion of the stress across the solid section under consideration, excludes discontinuities and concentrations, and is produced only by mechanical loads.

(9) S = code allowable stress value. The allowable stress shall correspond to the highest metal temperature at the section under consideration during the condition under consideration.

Note: Taken from the Hosgri Report, Table 7-1, "Hosgri Seismic Evaluations, Loading Combinations and Structural Criteria-Mechanical Equipment"

Support	Loading Combinations (3)	Criteria (4,5,6,7)
Linear Supports (2)	Deadweight + Seismic + Nozzle Loads	ASME Code Appendix XVII and Appendix F (Stresses not to exceed S_y for active components)
Plate and Shell (1) (Inactive Components)	Deadweight + Seismic + Nozzle Loads	σ_m $\leq 2.0S$ $(\sigma_m + \sigma_b)$ $\leq 2.4S$
Bolts	Deadweight + Seismic + Nozzle Loads	ASME Code Appendix XVII and/or Code Case 1644 plus Appendix F

(1) Plate and Shell Type Supports: Plate and shell type component supports are supports such as vessel skirts and saddles which are fabricated from plate and shell elements and are normally subjected to a biaxial stress field.

(2) Linear Type Support: A linear type component support is defined as acting under essentially a single component of direct stress. Such elements may also be subjected to shear stresses. Examples of such structural elements are: tension and compression struts, beams and columns subjected to bending, trusses, frames, rings, arches, and cables.

(3) Nozzle loads shall be those nozzle loads acting on the supported component during the Hosgri earthquake.

(4) σ_m = general membrane stress. This stress is equal to the average stress across the solid section under consideration, excludes discontinuities and concentrations, and is produced only by mechanical loads.

(5) Deleted

(6) σ_b = bending stress. This stress is equal to the linear varying portion of the stress across the solid section under consideration, excludes discontinuities and concentrations, and is produced only by mechanical loads.

(7) S = Code allowable stress value. The allowable stress shall correspond to the highest metal temperature at the section under consideration during the condition under consideration.

Note: Taken from the Hosgri Report, Table 7-2, "Hosgri Seismic Evaluation Loading Combinations and Structural Criteria Mechanical Equipment Supports"

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Appendix C

Key Term Definitions

(7 pages)

KEY TERMS AND DEFINITIONS USED IN THE HEAT EXCHANGER REPORT

(The definitions in this glossary establish the meanings of words in the context of their use in this document. These meanings in no way replace the specific legal and licensing definitions.)

Acceptance Criteria

- The comparison between the design analysis and the independent analysis where the results must agree within 15% and be below allowable. Failure to meet this acceptance criteria results in the issuance of an Open Item.

Allowable Criteria

- Maximum allowable stress or load provided by the licensing criteria.

ANCO, Inc.

- A PGandE seismic service-related contractor.

Axial Load

- Load acting on a member along the longitudinal axis.

Closed Item

- A form of program resolution of an Open Item which indicates that the reported aspect is neither an Error nor a Deviation. No further IDVP action is required (from Reference 17).

Completion Report

- Used to indicate that the IDVP effort related to the Open Item identified by the File Number is complete. It references either a Program Resolution Report which recategorized the item as a Closed Item or a PGandE document which states that no physical modification is to be applied in the case of a Deviation or a Class D Error (from Reference 17).

DCNPP-1

- Diablo Canyon Nuclear Power Plant, Unit 1

Design Codes

- Accepted industry standards for design (e.g., AISC, AISI, ANSI, ASME, AWWA, IEEE).

EOI

- Error and Open Item Report

Error Report

- An Error is a form of program resolution of an Open Item indicating an incorrect result that has been verified as such. It may be due to a mathematical mistake, use of wrong analytical method, omission of data or use of inapplicable data.

  Each Error shall be classified as one of the following:

  - Class A: An Error is considered Class A if design criteria or operating limits of safety related equipment are exceeded and, as a result, physical modifications or changes in operating procedures are required. Any PGandE corrective action is subject to verification by the IDVP.

  - Class B: An Error is considered Class B if design criteria or operating limits of safety related equipment are exceeded, but are resolvable by means of more realistic calculations or retesting. Any PGandE corrective action is subject to verification by the IDVP.

  - Class C: An Error is considered Class C if incorrect engineering or installation of safety related equipment is found, but no design criteria or operating limits are exceeded. No physical modifications are required, but if any are applied they are subject to verification by the IDVP.

  - Class D: An Error is considered Class D if safety related equipment is not affected. No physical modifications are required, but if any are applied, they are subject to verification by the IDVP (From Reference 17).

Equivalent static method

- Static analyses methodology whereby an acceleration figure is applied to the component configuration.

FSAR

- PGandE's Final Safety Analysis Report

Gusset

- A plate for attaching structural members at a joint.

Hosgri Criteria

- Licensing criteria referring specifically to the postulated 7.5M Hosgri earthquake.

Hosgri Report

- A report issued by PGandE that summarizes their evaluation of the DCNPP-1 for the postulated Hosgri 7.5M earthquake. Includes seismic licensing criteria.

Hosgri 7.5M Earthquake

- Maximum intensity earthquake for which the plant is designed to remain functional. Same as Safe Shutdown Earthquake (SSE).

Inertial Loads

- Loads produced by inertial motion of a body.

Interim technical reports

- Interim technical reports are prepared when a program participant has completed an aspect of their assigned effort in order to provide the completed analysis and conclusions. These may be in support of an Error, Open Item or Program Resolution Report or in support of a portion of the work which verifies acceptability. Since such a report is a conclusion of the program, it is subject to the review of the Program Manager. The report will be transmitted simultaneously to PGandE and to the NRC (From Reference 1).

Licensing Criteria

- Contained in PGandE Licensing Documents, includes allowable criteria (See Hosgri Report definition).

Membrane Stress

- Component of normal stress (perpendicular to the plane of reference) uniformly distributed and equal to the average value of stress across the thickness of the section under consideration.

NRC

- Nuclear Regulatory Commission.

NRC Order Suspending License CLI-81-30

- The order dated November 19, 1981 that suspended the license to load fuel and operate DCNPP-1 at power levels up to 5% of full power and specified the programs that must be completed prior to lifting of the suspension.

NSSS

- Nuclear Steam Supply System.

Open Item

- A concern that has not been verified, fully understood and its significance assessed. The forms of program resolution of an Open Item are recategorized as an Error, Deviation, or a Closed Item. (From Reference 17).

PGandE

- Pacific Gas and Electric Company.

Phase I Program

- Review performed by RLCA, RFR, and TES restricted to verifying work performed prior to June 1978, related to the Hosgri reevaluation design activities of PGandE and their service-related contractors.

Potential Program Resolution Report
and Potential Error Report

- Forms used for communication within IDVP.

Primary Stress

- A normal stress (perpendicular to the plane of reference) developed by the imposed loading which is necessary to satisfy the laws of equilibrium for external and internal forces and moments.

Program Resolution Report

- Used to indicate that the specific item is no longer active in the IDVP. It indicates whether the resolution is a Closed Item, a Deviation, or that responsibility for an Open Item has been transferred to the PGandE Technical Program. Further IDVP action is required upon completion of the associated PGandE Technical Program Task if the IDVP transfers an Open Item to PGandE or if physical modifications are applied with respect to a deviation (Reference 17).

Response

- The motion resulting from an excitation of a device or system under specified conditions.

Response Spectra

- Graph showing relationship between acceleration and frequency. Used in seismic analysis.

Response Spectra Modal Superposition

- Dynamic analysis methodology whereby responses are calculated separately on a mode-by-mode basis and then combined.

RLCA

- Robert L. Cloud and Associates, Inc.

Sample

- Initial sample stipulated in Phase I Program of equipment, components, and buildings to be design verified by independent analysis.

Sampling Approach

- Method used by the IDVP to determine the initial sample (buildings, piping, equipment and components) for analysis and to provide for sample expansion when required.

Sample Space

- All buildings, equipment and components evaluated for the Hosgri 7.5M earthquake by PGandE and their service-related contractors prior to June 1978.

Seismic

- Refers to earthquake.

Seismic Loads

- Loads produced by an earthquake.

Shear

- Parallel to the plane of reference.

Shear Keys

- Structural member inset in a slot or groove to resist planar forces.

Shell and Tube Exchanger

- A device for the transfer of heat from a hot fluid to a cooler fluid; one fluid passes through a group (bundle) of tubes; the other passes around the tubes through a surrounding shell.

Single Degree of Freedom Model

- Simplified mathematical representation of a structure.

SSE

- Safe Shutdown Earthquake: Maximum intensity earthquake for which the plant is designed to remain functional (Hosgri 7.5M).

SWEC

- Stone & Webster Engineering Corporation

TES

- Teledyne Engineering Services

Verification Program

- Undertaken by the IDVP to evaluate Diablo Canyon Nuclear Power Plant for compliance with the licensing criteria.

Appendix D

Program Manager's Assessment

(1 page)

APPENDIX D

PROGRAM MANAGER'S ASSESSMENT

Independent design verification of the Component Cooling Water Heat Exchanger (CCW HX) was performed in accordance with the Phase I Program Management Plan, Independent Design Verification Program, Engineering Procedure EP-1-014 and the Project Guide (Attachment 1 to EP-1-014). The verification effort involved visits to the RLCA offices and detailed discussion and review with the RLCA personnel of the analysis work performed by RLCA. Independent review of the RLCA calculations was carried out at the TES Waltham offices to verify that the method of analysis, the choice of computer program, and other analytical assumptions were appropriate and the hand calculations were numerically accurate.

The files issued by RLCA as Potential Program Resolution Reports or Potential Error Reports were reviewed thoroughly and specific recommendations were made to the IDVP Program Manager delineating appropriate resolution.

As a result of the verification of initial sampling selected by RLCA and the assessment of the impact of RLCA findings on the design adequacy of the Component Cooling Water Heat Exchanger, TES, as Program Manager, concludes that no additional verification or sampling is required.

INTERIM TECHNICAL REPORT 22
REVISION 1

VERIFICATION OF THE MECHANICAL/NUCLEAR PORTION OF THE AUXILIARY FEEDWATER SYSTEM

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April 25, 1983
J.O. No. 14296
DCS-396

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Washington, D. C. 20555

Mr. R. H. Engelken, Regional Administrator
Region V
U. S. Nuclear Regulatory Commission
1450 Maria Lane, Suite 210
Walnut Creek, CA 94596

Docket No. 50-275
Diablo Canyon Unit 1
License No. DPR-76

SWEC INTERIM TECHNICAL REPORTS

Gentlemen:

Attached are Interim Technical Report, Number 20, Revision 1, entitled "Verification of the Mechanical/Nuclear Design of the Control Room Ventilation and Pressurization System" and Interim Technical Report, Number 22, Revision 1, entitled "Verification of the Mechanical/Nuclear Portion of the Auxiliary Feedwater System."

Very truly yours,

John E. Krechting

J. E. Krechting
Project Engineer, Diablo Canyon Nuclear Power Plant

Enclosure

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PACIFIC GAS & ELECTRIC COMPANY

DIABLO CANYON NUCLEAR POWER PLANT

INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT NO. 22

REVISION 1

VERIFICATION OF THE MECHANICAL/NUCLEAR DESIGN OF THE AUXILIARY FEEDWATER SYSTEM

PERFORMED BY

STONE & WEBSTER ENGINEERING CORPORATION

DOCKET NO. 50-275

LICENSE NO. DPR-76

PROJECT MANAGER John E. Juckling for F. Sestak, Jr. DATE 4/20/83

PROGRAM MANAGER'S PREFACE

DIABLO CANYON NUCLEAR POWER PLANT - UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT

VERIFICATION OF THE MECHANICAL PORTION OF
THE AUXILIARY FEEDWATER SYSTEM

This is Revision 1 to the twenty-second of a series of Interim Technical Reports prepared by the DCNPP-IDVP for the purpose of providing a conclusion of the program.

This report provides the analytical results, recommendations and conclusions of the IDVP with respect to the initial sample.

As IDVP Program Manager, Teledyne Engineering Services (TES) has approved this ITR, including the conclusions and recommendations. The methodology followed by TES in performing this review and evaluation is described by Appendix B to this report.

ITR Reviewed and Approved
IDVP Program Manager
Teledyne Engineering Services

D.C. Stratouly

D.C. Stratouly
Assistant Project Manager

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

SECTION 1

INTRODUCTION

Stone & Webster Engineering Corporation (SWEC) reviewed the design of the Auxiliary Feedwater (AFW) System. The review was performed in accordance with the SWEC Scope of Work defined in Appendix D (DCNPP-IDVP-PP-002) of the IDVP Phase II Program Management Plan issued by Teledyne Engineering Services (TES) as IDVP Program Manager.

This Interim Technical Report (ITR) discusses the analysis of the Mechanical/Nuclear portion of the AFW System. Specific areas of review were:

- Existing system design compared to the Technical Specifications
- System redundancy
- Hydraulic design
- System specified design pressure and temperature
- Regulatory requirements
- Field verification of mechanical design.

Fire protection, high energy line breaks (HELBs), high energy line cracks (HELCs), and moderate energy line breaks (MELBs) as they affect the AFW System are addressed in separate ITRs.

For the mechanical portion of the AFW System, extensive documentation was both reviewed and prepared. These documents were also used for other scopes of work described in the other ITRs. PG&E documentation was supplied that included approximately:

- 600 pages of design criteria-related material
- 100 pages of Final Safety Analysis Report (FSAR) description
- 400 pages of related licensing documents and reports
- 150 drawings
- 30 equipment and component specifications.

In turn, the IDVP prepared documentation necessary for the review of this material. This review resulted in and was documented by approximately:

- 400 pages of documented review task packages
- 10 sketches and marked-up DCNPP-1 drawings
- 300 pages of calculations including 20 computer simulations of hydraulic characteristics
- 100 hours of field inspection
- 40 hours of technical exchange background meetings.

This review provided the IDVP a high degree of understanding concerning the licensing basis, as-built design, and performance characteristics of the AFW System.

SECTION 2

DEFINITION OF ITEMS REVIEWED

The following subsections provide a brief Scope of Work for the AFW System.

2.1 REVIEW OF THE AFW SYSTEM DESIGN FOR COMPATIBILITY WITH THE TECHNICAL SPECIFICATION REQUIREMENTS

The AFW system design was compared with the Technical Specification requirements. Items reviewed included water storage requirements, number of pumps required to operate for various modes of plant operation, and system surveillance testing requirements.

2.2 SYSTEM REDUNDANCY AND SINGLE FAILURE REVIEW

A review of redundancy and single failure was performed to determine if the AFW system design satisfies the single failure criteria as defined in the FSAR, Sections 3.1.1 and 10.4.8.

2.3 SYSTEM HYDRAULIC REVIEW

System hydraulic capabilities and Net Positive Suction Head available (NPSHa) were calculated and compared to licensing commitments and equipment capabilities. Pump driver power requirements were compared to installed driver capability.

2.4 SYSTEM DESIGN TEMPERATURE AND PRESSURE

The selected design pressures/temperatures for the piping, valves, fittings, and equipment were reviewed based on system operating conditions. Temperature conditions including the effects of outside environmental temperatures were evaluated.

2.5 REGULATORY REQUIREMENTS

A review of the applicable sections of NUREG 0578, 0611, 0660, 0694, and 0737 requirements and the PG&E commitments to the Standard Review Plan 10.4.9, Revision 1, was performed.

2.6 FIELD VERIFICATION

A field inspection was performed to confirm that the overall as-built AFW system arrangement is equivalent to that used in the various reviews and as identified in the licensing documents.

SECTION 3

DESCRIPTION OF REVIEW

Reviewing ITR No. 29, entitled "Design Chain - Initial Sample" determined the service-related contractors and/or internal PG&E engineering groups involved in the mechanical/nuclear design of the AFW System. The PG&E Mechanical Engineering Group was identified as being responsible for the mechanical/nuclear design of the AFW System. No service-related contractors were identified. The review also identified an interface between PG&E and Westinghouse for design criteria. The application of the Westinghouse design criteria to the AFW system design by PG&E was reviewed; however, the use of interface information by Westinghouse was not within the scope of this review. The DCNPP-1 licensing documents pertaining to the AFW System were reviewed and applicable licensing commitments were identified. The detailed review, described in the following sections, was then conducted to determine if the AFW system licensing commitments were satisfied.

3.1 REVIEW OF THE AFW SYSTEM DESIGN FOR COMPATIBILITY WITH THE TECHNICAL SPECIFICATION REQUIREMENTS

The Technical Specifications are part of the operating license for the DCNPP-1 and consist of a set of conditions which must be met during operation. The AFW system design was reviewed for compatibility with the specification requirements. The requirements can be grouped into the following areas with the applicable Technical Specification sections shown in parentheses.

- AFW system water supplies (Sections 3.7.1, 3/4.7.1, 3.3.3)
- Pump performance (Sections 4.7.1, 3/4.7.1)
- AFW system area temperature limits (Section 3.7.1)
- Power supply and load timer set points (Table 4.8-2).

Water supply requirements included minimum allowable volume and tank level indication. Westinghouse provided the minimum volume criteria for cold safe shutdown (Westinghouse letter J. S. Fuoto to D. V. Kelley of PG&E, dated December 2, 1975). SWEC performed an independent calculation to verify that the condensate storage tank capacity (primary AFW supply) meets Westinghouse and Technical Specification criteria.

Pump performance requirements included minimum pump head and minimum flow rate. Pump head requirements were compared to the pump vendor head versus flow curves. The hydraulic calculations described in Section 3.3 were used to verify that required flow rates could be met.

AFW system area temperature limits were specified for both the motor-driven pump room and the area containing level control valves LCV 113 and LCV 115. Location and control drawings were checked to determine if temperature indicators and recorders were provided for these areas.

An electrical and control circuit review was made of the power supply and load timer set points, as well as the minimum time for AFW system operation to verify that Technical Specification requirements were met.

The In-Service Inspection and Testing Program Plan plus the Technical Specification Section 4.7.1 were reviewed to evaluate acceptance criteria for pump performance.

3.2 SYSTEM REDUNDANCY AND SINGLE FAILURE REVIEW

Piping schematics and drawings depicting the power supply and control circuits to components were reviewed to determine the capability of the AFW System to meet the single failure criteria, as described in FSAR Sections 3.1.1 and 10.4.8. Various single active or passive failures were postulated, including failure of a diesel generator or failure of individual components, such as pumps, valves, piping, or instrumentation. Their effects on the AFW System were evaluated. Loss of all offsite power was assumed to occur simultaneously with the postulated failure in all cases.

3.3 SYSTEM HYDRAULIC REVIEW

The AFW System was hydraulically modeled with the computer program "HY-66 - Piping System Analysis Program," using the latest PG&E piping drawings and component hydraulic characteristics. Computer Program HY-66 has been documented in accordance with the requirements of the Stone & Webster Standard Nuclear Quality Assurance Program. A calculation was performed to compare the computer program results with actual test data. The comparison was made to determine that the model could duplicate system characteristics within ±10 percent. This computer model was used to independently verify that flow rates identified in FSAR Sections 6, 10, 15, 16, and PG&E responses to

NRC IE Bulletin 80-04 were calculated correctly by PG&E. Accident conditions and shutdown flows were also verified. For feedwater and main steam line break accidents, flow through the break and flows to the intact steam generators were verified. Various component failures were evaluated to determine worst case flows. NPSHa to the operating pumps was calculated for all flow conditions, and the calculated NPSHa was compared to the required NPSH shown on pump vendor documentation. The piping drawings were compared to the piping schematics to confirm that the system arrangement was correct for hydraulic modeling purposes.

The required motor horsepower for the motor-driven AFW pumps was calculated and compared to vendor documentation for compatibility. The turbine driver size was reviewed for capability and the capacity of its steam lines to provide the required flow was determined. The set points of the Runout Control System were reviewed and a failure analysis of the system was made to determine the effects on the AFW System. Time to deliver water to the steam generators was reviewed against Technical Specification Section 3.3.2 and FSAR Section 7.4.1. Additionally, logic diagrams were reviewed to determine if steam generator blowdown and sampling lines were isolated as specified in FSAR Section 10.4.8. The FSAR Chapter 15 accident analyses requiring AFW system operation (refer to PG&E to NRC letter, dated October 9, 1980, which responded to NRC requests for information concerning the design basis of the AFW system) assumed the blowdown valves were shut during the period when the auxiliary feedwater is operating.

3.4 SYSTEM DESIGN TEMPERATURE AND PRESSURE

The major items reviewed included the following:

- Specification of design pressure for pipe fittings, equipment, and stress input

- The isolation of low pressure components and piping from the effects of the higher pressure portion of the system

- A review of all equipment and components for compatibility with the specified design pressure.

FSAR Tables 3.2-3 and 3.2-4 were reviewed to identify the applicable piping codes. Technical documentation including PG&E line designation tables, specifications, drawings, and calculations were reviewed to identify the design basis.

An independent calculation and analysis were made to determine if the selected design pressure met the applicable piping code requirements. The pump curves, arrangement drawings, and the piping code were used as the basis for the calculation of system design pressure. Piping schematics were reviewed to determine if low pressure components could be exposed to high pressure sources.

The FSAR Sections 1, 2, 3, and 9 and Appendix 29, site weather information documents, and piping drawings were used to determine if the common suction line was susceptible to freezing.

3.5 REGULATORY REQUIREMENTS

Correspondence between PG&E and the NRC was reviewed to identify specific commitments concerning modifications that would be made as a result of the Three Mile Island (TMI) event. The PG&E responses to NUREG Documents 0578, 0611, 0660, 0694, and 0737 were specifically reviewed to identify licensing commitments.

A comparison was made between the "NRC Standard Review Plan - Auxiliary Feedwater System" SRP 10.4.9, Revision 1, and PG&E's commitments regarding this SRP in its letter of March 13, 1980. The system design was reviewed to verify these commitments were met.

3.6 FIELD VERIFICATION

A field verification was made of the AFW System to confirm its overall as-built arrangement; however, this verification did not include the dimensional accuracy of pipe lengths as it applies to pipe stress analysis. The as-built piping configuration was compared to the piping drawings to assure no significant differences exist from a hydraulic operational viewpoint. Specific items of review included:

- A walkdown to determine if the overall as-built system was equivalent to the piping schematics. Items checked included: line size, sequence of piping branch connections, installation of major components, approximate piping lengths compared to the piping drawings, and equipment elevations.

- The ability to cross-connect the various water supplies to the AFW pumps suction was reviewed including the condensate storage tank, firewater storage tank, reservoir, and seawater.

- The condensate storage tank configuration was reviewed to determine that it met the licensing commitments set forth in FSAR Section 9, FSAR Appendix 2, and SER Supplements 7 and 8.

- The steam supply to the turbine-driven AFW pump was reviewed for configuration and location of steam traps.

- The system valve type, pressure rating, manufacturer, and model number were reviewed.

- TMI-related modifications were reviewed.

SECTION 4

SUMMARY OF REVIEW RESULTS

This section provides a summary of the review results and identifies all concerns raised as a result of this review.

4.1 REVIEW OF THE AFW SYSTEM DESIGN FOR COMPATIBILITY WITH THE TECHNICAL SPECIFICATION REQUIREMENTS

Within the scope of the IDVP Phase II Program Management Plan, the system design was compatible with the applicable requirements of the Technical Specifications. The AFW pumps can be tested in accordance with the Technical Specification Section 4.7.1 requirements.

The condensate storage tank was found to contain sufficient reserve volume to meet the NSSS vendor criteria (Westinghouse letter J. S. Fuoto to D. V. Kelley of PG&E, dated December 2, 1975), and a level switch initiates an alarm in the control room before the minimum volume is reached. The tank was also found to conform to all Technical Specification requirements (Sections 3.7.1, 3/4.7.1, 3.3.3). The required level indication at the hot shutdown panel was also located.

Review of the electrical drawings indicated that area temperature limits for the motor-driven pump room and the LCV area are monitored and recorded by temperature recorders. Logic diagrams indicate that when the temperature rises 1 degree Fahrenheit above the design limit, an alarm is sounded in the control room.

Power supply and load timer set points, as well as the minimum time required for AFW system operation, were specifically stated in the Technical Specification Table 4.8-2. This review of design documents verified the system design met the required Technical Specifications.

4.2 SYSTEM REDUNDANCY AND SINGLE FAILURE REVIEW

The review verified that the AFW System has adequate mechanical and electrical redundancy to meet the single failure criteria of FSAR Sections 3.1.1 and 10.4.8 and can perform its intended safety function.

4.3 SYSTEM HYDRAULIC REVIEW

The AFW System was hydraulically modeled with a computer program (HY-66) to calculate system pressure and flow rates in the various operating modes and accident conditions. The computer program comparison to test data confirmed that the model could reproduce system characteristics.

The accident analysis calculations verified that the PG&E calculated flows that are documented in PG&E response to NRC IE Bulletin 80-04 of April 30, 1980, and FSAR Section 15.4.2 were conservative and, thus, acceptable. The calculated flow for normal shutdown and cooldown verified for all possible pump combinations, including single pump operation, that the committed flow rates in FSAR Sections 6, 10, and 16 can be obtained. In addition, NPSHa during accident and normal shutdown conditions always exceeded the vendor required NPSH.

The AFW system piping schematic versus piping drawing review resulted in only minor discrepancies, such as vent and drain placement. Differences were evaluated, and none were found that would affect safety, the hydraulic analysis, or licensing commitments.

The review of the motor-driven pump performance, using the most recent field test data, verified that the pumps are capable of performing their function without exceeding the nameplate motor horsepower. The review of turbine steam supply line size and turbine characteristics indicates the turbine-driven pump can supply the minimum required flow specified in FSAR Sections 6, 10, and 16 over the expected range of steam generator pressures.

The review of system response time and blowdown and sampling line isolation circuits verified that all applicable licensing commitments from Technical Specification Section 3.3.2 and FSAR Section 10.4.8 were met. The diesel generator loading logic diagrams indicated full system flow will be available within the committed time from Technical Specification Table 8.3-5 and FSAR Section 7.4.1. System logic diagrams indicated the blowdown and sampling line valves receive a signal to close on automatic AFW system start.

Computer hydraulic analyses performed using the runout control set points indicated that less than the minimum required flow may be produced under certain operating conditions. As a result, a concern over the design of the safety grade flow limiting control scheme provided to prevent a motor-driven AFW pump from running out on its pump curve in the event of a depressurized steam generator was identified. Control valves LCV 110, 111, 113, and 115

normally respond to steam generator level. The addition of the runout control logic results in the valves responding to pump discharge pressure when the pressure decreases to 1,360 psig. At 1,310 psig, the pressure signal will provide the maximum flow limiting signal to the control valve which results in the valve closing. The level control signal and the pressure control signal may, at times, be commanding the valve to perform opposite functions simultaneously. A concern existed that the flow limiting feature, utilizing a pressure and level control loop linked to one valve, would not perform its intended function without adverse interaction during all modes of operation. The analyses indicated that the pressure control set points may not be low enough to permit the minimum required flow to the steam generators when only one motor-driven pump is operating.

PG&E provided a resolution for this concern which consists of set point changes and startup testing for dynamic stability. The resolution has been reviewed and an analysis of the new set points has been performed. Based on the analysis of the new set points and the commitment to perform appropriate startup testing of the Runout Control System, the resolution is acceptable.

4.4 SYSTEM DESIGN TEMPERATURE AND PRESSURE

The review of the selected design pressure for piping, fittings, components, and mechanical equipment, determined that the applicable design codes for selection of design pressure were not met. These design codes require the system to be designed for the most severe condition of coincident pressure, temperature, and other loading. Additionally, the effects of static head, maximum sustained pressure at any pump load per ANSI B31.1 102.2.5(e) and

pressure surges must be accounted for. The design pressure shown in the Line Designation Table does not meet the requirements of the code based on:

- Selecting 1,300 psia as a design pressure from a pump curve based on nominal TDH at design flow. This does not account for suction conditions or lower pump operational flows.

- The selected design pressure of 1,300 psia does not envelop the sustained pressure developed during recirculation mode, including suction static head, as documented in the Pre-Op Test Procedure 3.7 of September 15, 1980.

- Under many operating conditions, including rated flow, but particularly reduced flow operation, the 1,300 psia is exceeded (Pre-Op Test Procedure 3.1, Addendum 1, October 25, 1978).

- The "K16" pipe specification rating is exceeded under some operational conditions including operation in the recirculation mode.

- ANSI B16.5 900# flange ratings and valve ratings are exceeded under turbine overspeed conditions at reduced flows and in the recirculation mode.

In addition, the pipe stress analysis may be nonconservative due to use of a low design pressure.

PG&E provided a resolution for this concern which consists of lowering the turbine overspeed trip set point, recalculating system design pressure, and replacing system components which are rated below the new design pressures. Independent calculations were performed to verify the new design pressures are code acceptable and to determine whether equipment ratings will be adequate. The analysis showed that the new design pressures are code acceptable and the adequacy of equipment ratings will be determined after the modifications are complete.

The protection of low pressure components and piping from the effects of high pressure sources was reviewed. It was determined that the applicable design code was not met. A valve was added by DCO-E-M-472 that provides additional backpressure and flow through the turbine bearing coolers. Prior to this change, the system was code acceptable with the existing valve acting as the division valve. The added throttle valve effectively becomes the division valve, now violating Paragraph 102.2.5(a) of ANSI B31.1. Additionally, the original valve is equivalent to a pressure reducing valve per P 102.2.5(b). The low pressure portion does not have pressure relieving components downstream, violating Paragraph 102.2.5(b). The piping and components are not adequately protected against surges and a variety of operating conditions including:

- Operating when aligned to the reservoir resulting in higher discharge pressure

- Turbine overspeed (testing or inadvertent)

- Throttled pump 1-1 or running in recirculation mode

- Running pumps 1-1, 1-2, and 1-3 resulting in higher backpressure in the recirculation return line

- Inadvertent operation of valves including the valve with the handwheel removed and Valve 22 in the bearing common discharge piping to the 1-1 pump suction.

PG&E has provided a resolution for this concern which consists of modifications to the turbine pump recirculation lines. A design change has been issued to implement these modifications. This design change has been reviewed against the applicable code requirements for separation of low pressure piping from higher pressure piping. The proposed changes are in compliance with the code.

The review of components, by evaluating specification and manufacturer's data, showed they were compatible with the existing specified pressure/temperature. These items were re-evaluated in the design pressure resolution.

A review of valve actuator sizing indicated FCV 37, FCV 38, and FCV 95 were designed to open and close against a maximum differential pressure of 805 psi. These valves could be required to operate against a differential pressure in excess of 1,100 psi. As an example, FCV 95 may be required to open during conditions where steam generator safety valves are lifting.

PG&E has provided a resolution for this concern which consists of modifications to the gear ratio of the FCV 95 actuator in accordance with manufacturer's recommendations. It has been determined that FCV 37 and FCV 38 do not require modifications because these valves are not required to operate for safe shutdown of the plant.

The AFW pump suction line from the condensate storage tank is common to all three pumps for a portion of the system and was reviewed for susceptibility to freezing conditions. Based on the site temperature data and the location of piping, the common suction line was judged not to be susceptible to freezing.

4.5 REGULATORY REQUIREMENTS

The review of licensing correspondence and commitments identified in Section 3.5 of this report was compared to the system design. This comparison review indicated all commitments have been implemented.

4.6 FIELD VERIFICATION

The field verification resulted in two concerns regarding approved design changes that were not made to the system; however, PG&E provided a resolution subsequent to the field verification that resulted in a conclusion that no technical concerns exist in the actual field installation of the system.

One concern involved the AFW steam supply to the AFW turbine. PG&E believed that condensate from steam line 593 (steam supply to the AFW turbine) was the cause of problems encountered during AFW turbine cold start testing. Design Change DC-1-G-M-1017 was written to add an additional steam trap to line 593 between traps 104 and 105. Piping Schematic 102004, Sheet 5, was revised in Change 10 to show the trap, but the piping drawing (500058, Coordinate D-10) and the field piping have not been changed. The concern was that excessive condensate may be present during operation and could contribute to turbine cold start difficulties including overspeed trip; however, startup testing performed successfully (DCP Procedure 3.7) without the steam trap in place.

The other concern involved the long-term cooling water supply system. Design Change DCO-E-M-404 R1 replaced a hose station with a single valve and cap. Piping Schematic 102016, Sheet 5A, was revised to reflect the change. Design Change DCO-G-M-2264 added a relief valve for overpressure protection and the drawing was revised again. A check valve in the manifold line originally shown in Revision 8 of the Piping Schematic, and shown to be removed in DCO-E-M-404 R1, was identified in the field as installed; however, current documentation shows it removed. The concern was that safety-related modifications were not implemented in the field. PG&E resolution for this concern stated that the drawings were mistakenly revised but that the field installation is acceptable according to DCO-E-M-404-R1. It was determined that the field design is acceptable as is and no technical concern exists.

SECTION 5

EOI REPORTS ISSUED

Seven EOI files have been issued for the verification of the Mechanical/ Nuclear portion of the AFW System. The status of these files is summarized in Appendix A.

EOI File 8009 was issued because the most severe design condition of coincident pressure, temperature, and other loadings had not been considered in system design pressure and temperature selection. PG&E has re-evaluated the AFW system design temperature/pressure and has provided a resolution for this file which involves physical modifications. This resolution has been reviewed and found acceptable. The file remains open as an Error Class A pending IDVP verification of the modifications.

EOI File 8010 was issued because the inclusion of a valve in the system to provide additional backpressure and flow through the turbine bearing coolers violates the ANSI Code and leaves some components unprotected against pressures resulting from a variety of operating conditions. PG&E has provided a resolution changing the piping configuration on the turbine pump recirculation line. The change will be code acceptable. The file remains open as an Error Class A pending IDVP verification of the modifications.

EOI File 8015 was issued because the Technical Specification describing testing of the AFW pumps does not require measurement of pump flow during testing. The NRC has approved the Technical Specifications. The AFW system design does not permit pump testing in accordance with the Technical

Specifications. The licensing commitment is satisfied. This file has been closed.

EOI File 8027 was issued because a design change (to add an additional steam trap) was issued, but field piping does not show this change. The concern is that safety-related modifications were not made in the field. There are no technical concerns with the existing configuration. Design change procedures are addressed in the R.F. Reedy Scope of Work.

EOI File 8048 was issued because safety-related modifications were not implemented according to approved documents. There are no technical concerns with the existing configuration. Design change procedures will be reviewed.

EOI File 8060 was issued because of the concern that the AFW Runout Control System will interfere with the delivery of design flow to the steam generators. PG&E has provided a resolution involving changes to the runout control set points and startup testing of the Runout Control System. This resolution is acceptable. This file has been closed.

EOI File 8062 was issued due to the concern that the valve actuators may be undersized. PG&E has provided a resolution consisting of changes to FCV 95 and a licensing basis of why FCV 37 and FCV 38 are acceptable as designed. This resolution has been reviewed and accepted. The file remains open as an Error Class A pending IDVP verification of the modifications to FCV 95.

SECTION 6

EVALUATION OF REVIEW RESULTS

6.1 REVIEW OF THE AFW SYSTEM DESIGN FOR COMPATIBILITY WITH THE TECHNICAL SPECIFICATION REQUIREMENTS

The AFW system design is compatible with the Technical Specification requirements. The IDVP acceptance criteria are met.

6.2 SYSTEM REDUNDANCY AND SINGLE FAILURE REVIEW

The system equipment redundancy and its ability to withstand a single failure were reviewed and found acceptable. Redundant sources of water for the AFW System that have been extensively reviewed by the NRC are provided. A single manual valve in the common suction line from the condensate storage tank was identified by a PG&E system reliability analysis and locked open to minimize the possibility of the valve being inadvertently shut which would isolate the initial source of water to the AFW System. This valve was confirmed during the field verification as being permanently locked open. The IDVP acceptance criteria are met.

6.3 SYSTEM HYDRAULIC REVIEW

The hydraulic review confirmed that the minimum required flow could be provided as required in the DCNPP-1 licensing documents identified in Section 4.3 and that flows submitted to Westinghouse were conservative when compared

to the independent calculated flow rates. The IDVP acceptance criteria are met.

6.4 SYSTEM DESIGN TEMPERATURE AND PRESSURE

Based on the response to identified concerns on design pressure and temperature selection and specification of maximum differential pressure used for valve actuator sizing, it has been determined that generic concerns exist which are discussed in ITR No. 34.

6.5 REGULATORY REQUIREMENTS

The regulatory requirements identified in Section 3.5 of this report and the commitments made concerning them were reviewed. The commitments reviewed were implemented as stated. The IDVP acceptance criteria are met.

6.6 FIELD VERIFICATION

Two EOI files identified approved design changes that were not implemented in the field. Design change procedures are addressed under the R. F. Reedy Scope of Work. No technical concerns exist. The as-built configuration of the AFW System is equivalent to the configuration used in the various IDVP reviews and identified in the licensing documents. The IDVP acceptance criteria are met.

SECTION 7

CONCLUSIONS

The following sections summarize whether additional verification or additional sampling of the items reviewed is required.

7.1 REVIEW OF THE AFW SYSTEM DESIGN FOR COMPATIBILITY WITH THE TECHNICAL SPECIFICATION REQUIREMENTS

No additional verification or sampling is required.

7.2 SYSTEM REDUNDANCY AND SINGLE FAILURE REVIEW

No additional verification or sampling is required.

7.3 SYSTEM HYDRAULIC REVIEW

No additional verification or sampling is required.

7.4 SYSTEM DESIGN TEMPERATURE AND PRESSURE

Additional verification of PG&E designed safety-related systems is required to determine if design temperatures and pressures were developed in accordance with the applicable code and whether valve actuators are properly sized for differential pressure. This additional verification is further discussed in ITR No. 34.

7.5 REGULATORY REQUIREMENTS

No additional verification or sampling is required.

7.6 FIELD VERIFICATION

No additional verification or sampling is required.

APPENDIX A

EOI FILES

APPENDIX A

DCNPP IDVP STATUS REPORT

	REV. 0	LATEST REV.				PG&E ITR	
FILE NO.	DATE	REV.	DATE	BY	STATUS	MODS	SUBJECT
8009	820913	0	820913	SWEC	OIR		EVAL. OF COMPLIANCE W/ANSI CODE OF AFW PIPING
8009	820913	1	821001	SWEC	PPRR/OIP		EVAL. OF COMPLIANCE W/ANSI CODE OF AFW PIPING
8009	820913	2	821022	TES	PRR/OIP		EVAL. OF COMPLIANCE W/ANSI CODE OF AFW PIPING
8009	820913	3	830113	TES	OIR		EVAL. OF COMPLIANCE W/ANSI CODE OF AFW PIPING
8009	820913	4	830214	SWEC	PER/A		EVAL. OF COMPLIANCE W/ANSI CODE OF AFW PIPING
8009	820913	5	830225	TES	ER/A	YES	EVAL. OF COMPLIANCE W/ANSI CODE OF AFW PIPING
8009	820913	6	830309	SWEC	PER/A	YES	EVAL. OF COMPLIANCE W/ANSI CODE OF AFW PIPING
8009	820913	7	830309	TES	ER/A	YES	EVAL. OF COMPLIANCE W/ANSI CODE OF AFW PIPING
8010	820913	0	820913	SWEC	OIR		EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8010	820913	1	820913	SWEC	OIR		EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8010	820913	2	821001	SWEC	PPRR/OIP		EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8010	820913	3	821022	TES	OIR		EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8010	820913	4	821029	SWEC	PER/A		EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8010	820913	5	821105	TES	ER/A		EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8010	820913	6	830113	TES	OIR	YES	EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8010	820913	7	830304	SWEC	PER/A	YES	EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8010	820913	8	830310	TES	ER/A	YES	EVAL. OF COMPLIANCE W/ANSI CODE BEARING COOLER
8015	820927	0	820927	SWEC	OIR		AUX FW SYS FLOW CAPACITY
8015	820927	1	821001	SWEC	PPRR/OIP		AUX FW SYS FLOW CAPACITY
8015	820927	2	821022	TES	OIR		AUX FW SYS FLOW CAPACITY
8015	820927	3	821029	SWEC	PER/B		AUX FW SYS FLOW CAPACITY
8015	820927	4	821105	TES	ER/B		AUX FW SYS FLOW CAPACITY
8015	820927	5	830103	TES	OIR		AUX FW SYS FLOW CAPACITY
8015	820927	6	0				AUX FW SYS FLOW CAPACITY
8015	820927	7	830210	SWEC	PPRR/CI		AUX FW SYS FLOW CAPACITY
8015	820927	8	830225	TES	PRR/OIP		AUX FW SYS FLOW CAPACITY
8015	820927	9	830225	TES	PRR/CI		AUX FW SYS FLOW CAPACITY
8015	820927	10	830225	TES	CR	NO	AUX FW SYS FLOW CAPACITY
8027	821013	0	821013	SWEC	OIR		AFWS STEAM SUPPLY TO THE AFW TURBINE
8027	821013	1	821014	SWEC	PPRR/OIP		AFWS STEAM SUPPLY TO THE AFW TURBINE
8027	821013	2	821029	TES	PRR/OIP		AFWS STEAM SUPPLY TO THE AFW TURBINE
8027	821013	3	830113	TES	OIR		AFWS STEAM SUPPLY TO THE AFW TURBINE
8027	821013	4	830209	SWEC	PPRR/CI		AFWS STEAM SUPPLY TO THE AFW TURBINE
8027	821013	5	830211	TES	PRR/CI		AFWS STEAM SUPPLY TO THE AFW TURBINE
8027	821013	6	830211	TES	CR	NO	AFWS STEAM SUPPLY TO THE AFW TURBINE
8048	821025	0	821025	SWEC	OIR		AFW LONG TERM COOLING WATER SUPPLY SYSTEM
8048	821025	1	821025	SWEC	PPRR/OIP		AFW LONG TERM COOLING WATER SUPPLY SYSTEM
8048	821025	2	821029	TES	PRR/OIP		AFW LONG TERM COOLING WATER SUPPLY SYSTEM
8048	821025	3	830111	TES	OIR		AFW LONG TERM COOLING WATER SUPPLY SYSTEM
8048	821025	4	830209	SWEC	PPRR/CI		AFW LONG TERM COOLING WATER SUPPLY SYSTEM
8048	821025	5	830211	TES	PRR/CI		AFW LONG TERM COOLING WATER SUPPLY SYSTEM
8048	821025	6	830211	TES	CR	NO	AFW LONG TERM COOLING WATER SUPPLY SYSTEM
8060	821029	0	821029	SWEC	OIR		AFW CONTROLS FOR LIMITING FLOW TO DEP.STEAM GEN.
8060	821029	1	821109	SWEC	PPRR/OIP		AFW CONTROLS FOR LIMITING FLOW TO DEP.STEAM GEN.
8060	821029	2	821123	TES	PRR/OIP		AFW CONTROLS FOR LIMITING FLOW TO DEP.STEAM GEN.
8060	821029	3	830302	TES	OIR		AFW CONTROLS FOR LIMITING FLOW TO DEP.STEAM GEN.
8060	821029	4	830311	SWEC	PER/C		AFW CONTROLS FOR LIMITING FLOW TO DEP.STEAM GEN.
8060	821029	5	830315	TES	ER/C		AFW CONTROLS FOR LIMITING FLOW TO DEP.STEAM GEN.
8060	821029	6	830315	TES	CR	NO	AFW CONTROLS FOR LIMITING FLOW TO DEP.STEAM GEN.
8062	821118	0	821118	SWEC	OIR		AFW CONTROL VALVES FCV37,39 AND 95.

APPENDIX A (CONT)

ICNPP IDVP STATUS REPORT

	REV. 0	LATEST REV.				PG&E ITR	
FILE NO.	DATE	REV.	DATE	BY	STATUS	MODS	SUBJECT
8062	821116	1	821116	SWEC	PPR/OIP		AFW CONTROL VALVES FCV37, 38, & 95.
8062	821116	2	821122	TES	PRR/OIP		AFW CONTROL VALVES FCV37, 38, & 95.
8062	821116	3	830219	TES	OIR		AFW CONTROL VALVES FCV37, 38, & 95.
8062	821116	4	830304	SWEC	PER/A		AFW CONTROL VALVES FCV37, 38, & 95.
8062	821116	5	830310	TES	ER/A	YES	AFW CONTROL VALVES FCV37, 38, & 95.

APPENDIX B

PROGRAM MANAGER'S ASSESSMENT

APPENDIX B

PROGRAM MANAGER'S ASSESSMENT

Independent review by TES of the tasks performed by SWEC to verify the Mechanical/Nuclear portion of the AFW System was done in accordance with IDVP Phase II Program Management Plan dated June 18, 1982 and the Engineering Procedure EP-1-014.

The review involved several visits to the site and the SWEC offices for detailed discussions and review, with SWEC personnel, of the work performed by SWEC including the methodology used in this task.

The files issued by SWEC were reviewed thoroughly and specific recommendations were made to the IDVP Program Manager delineating appropriate resolution.

As a result of the verification of initial sampling selected by SWEC and the assessment of the impact of SWEC's findings, TES, as Program Manager, is of the opinion that because of the concern of design pressure and temperature selection and specification of maximum differential pressure used for valve actuator sizing, additional verification is required.

INTERIM TECHNICAL REPORT 20
REVISION 1

Verification of the Mechanical/Nuclear Design of the Control Room Ventilation and Pressurization System

STONE & WEBSTER ENGINEERING CORPORATION

STONE & WEBSTER ENGINEERING CORPORATION

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April 25, 1983
J.O. No. 14296
DCS-396

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Docket No. 50-275
Diablo Canyon Unit 1
License No. DPR-76

SWEC INTERIM TECHNICAL REPORTS

Gentlemen:

Attached are Interim Technical Report, Number 20, Revision 1, entitled "Verification of the Mechanical/Nuclear Design of the Control Room Ventilation and Pressurization System" and Interim Technical Report, Number 22, Revision 1, entitled "Verification of the Mechanical/Nuclear Portion of the Auxiliary Feedwater System."

Very truly yours,

John E. Krechting

J. E. Krechting
Project Engineer, Diablo Canyon Nuclear Power Plant

Enclosure

cc: RRFray (45)
RFReedy
ETDenison
WECooper (10)
HShierling (40)
MJStrumwasser
DFFleischaker
JRReynolds
BNorton
ACGehr
RHubbard
JRPhillips
JRoesset

Dupe PDR
~~8305030538~~

PACIFIC GAS & ELECTRIC COMPANY

DIABLO CANYON NUCLEAR POWER PLANT

INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT NO. 20

REVISION 1

VERIFICATION OF THE MECHANICAL/NUCLEAR DESIGN OF THE CONTROL ROOM VENTILATION AND PRESSURIZATION SYSTEM

PERFORMED BY

STONE & WEBSTER ENGINEERING CORPORATION

DOCKET NO. 50-275

LICENSE NO. DPR-76

PROJECT MANAGER John E Gucktery DATE 4/20/83

for F. Sestak, Jr.

Dupe PDR

~~8305030545~~

PROGRAM MANAGER'S PREFACE

DIABLO CANYON NUCLEAR POWER PLANT - UNIT 1

INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT

VERIFICATION OF THE MECHANICAL/NUCLEAR DESIGN OF THE

CONTROL ROOM VENTILATION AND PRESSURIZATION SYSTEM

This is Revision 1 to the twentieth of a series of Interim Technical Reports prepared by the DCNPP-IDVP for the purpose of providing a conclusion of the program.

This report provides the analytical results, recommendations and conclusions of the IDVP with respect to the initial sample.

As IDVP Program Manager, Teledyne Engineering Services has approved this ITR including the conclusions and recommendations. The methodology followed by TES in performing this review and evaluation is described by Appendix B to this report.

ITR Reviewed and Approved
IDVP Program Manager
Teledyne Engineering Services

D. C. Stratouly
Assistant Project Manager

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

SECTION 1

INTRODUCTION

Stone & Webster Engineering Corporation (SWEC) has reviewed the design of the Control Room Ventilation and Pressurization System (CRVP) in accordance with the SWEC Scope of Work defined in Appendix D (DCNPP-IDVP-PP-002) of the IDVP Phase II Program Management Plan issued by Teledyne Engineering Services (TES) as IDVP Program Manager. The review included control room cooling load; system air flow rates; applicable codes, standards and regulatory guides; system design temperatures and pressures; control room habitability; Technical Specifications; system redundancy; and a field inspection. The scope of this review is amplified below.

This Interim Technical Report (ITR) does not address the review of fire protection, high energy line break (HELB) or high energy line crack (HELC) or moderate energy line break (MELB) effects on the CRVP System. These reviews are discussed in separate ITRs.

For the mechanical portion of the CRVP System, extensive documentation was both reviewed and prepared. These documents may also have been used for other Scopes of Work described in other ITRs. PG&E documentation was supplied that included approximately:

- 20 pages of FSAR description
- 200 pages of related licensing documents and reports
- 70 drawings including circuit schematics and wiring diagrams
- 30 specifications.

In turn, the IDVP prepared documentation necessary for the review of this material. This review resulted in and was documented by approximately:

- 300 pages of documented review task packages
- 5 sketches and marked-up drawings
- 70 pages of calculations
- 100 hours of field inspection
- 40 hours of technical exchange background meetings.

This review provided the IDVP a high degree of understanding concerning the licensing basis, as-built design, and performance characteristics of the CRVP System.

SECTION 2

DEFINITION OF ITEMS REVIEWED

The following subsections provide a brief Scope of Work for the CRVP System review.

2.1 CONTROL ROOM COOLING LOAD

Total system required cooling load was checked against the equipment capacity for all four design modes of operation.

2.2 SYSTEM AIR FLOW RATES

The required static pressures and flows were compared against the fans' actual capabilities for all four design modes of operation. The system air flow requirements were checked against the actual system flow capability for all four design modes of operation.

2.3 CODES, STANDARDS, AND REGULATORY GUIDES

The codes, standards, and regulatory requirements applicable to the CRVP system design were reviewed.

2.4 SYSTEM DESIGN TEMPERATURES AND PRESSURES

System design temperatures and pressures specified were checked for all operating conditions. The system's compatibility with the specified design pressure and temperature was reviewed.

2.5 CONTROL ROOM HABITABILITY

The ability of the CRVP System to maintain control room habitability was reviewed based on the radiological and toxic environments identified in the DCNPP-1 licensing documents for the four design modes of operation, adverse environmental occurrences, and subsequent to postulated accidents.

2.6 TECHNICAL SPECIFICATIONS REVIEW

The Technical Specifications requirements were reviewed to determine compatibility with the CRVP system design.

2.7 SYSTEM REDUNDANCY (OPERABILITY AND FUNCTIONABILITY)

A review of redundancy was performed to determine whether the CRVP system design satisfies the single failure criteria as defined in the DCNPP-1 licensing documents.

2.8 FIELD INSPECTION

A field inspection was performed to verify that the as-built conditions of the CRVP System compared to the design documents and drawings used for IDVP review.

SECTION 3

DESCRIPTION OF REVIEW

ITR No. 29, entitled "Design Chain - Initial Sample" was reviewed to determine the service-related contractors and internal PG&E engineering groups involved in the mechanical design of the CRVP System. The results of this review identified EDS Nuclear, Inc., as the only service-related contractor. The PG&E Civil Engineering Group was directly involved in the mechanical design of the CRVP System. The responsibilities and interfaces between the service-related contractor and the PG&E Engineering Group were identified. The DCNPP-1 licensing documents pertaining to the CRVP System were reviewed and applicable licensing commitments were identified. The detailed review discussed below was conducted to determine whether the CRVP system licensing commitments were met. The detailed reviews described below assumed single failures consistent with DCNPP-1 licensing commitments.

3.1 CONTROL ROOM COOLING LOAD

An independent calculation was performed to determine the total required cooling capacity of the CRVP system's air-conditioning equipment for the four design modes of operation described in FSAR Section 9.4.1. This was done by identifying the major equipment in the control room during a site visit. Vendor data, nameplate data, and conservative equipment efficiencies were used to determine the amount of heat rejected into the control room. Outside design air conditions identified in FSAR Section 9.4 and equipment

rejected heat were used to determine the maximum cooling load the air-conditioning equipment would have to accommodate under the four modes of operation.

These maximum cooling loads were compared to the capacity of the air-conditioning equipment identified on vendor data. The resulting control room temperatures were independently calculated using vendor data for the cooling coil, and compared to the design temperature committed to in the FSAR Section 9.4.1. The calculated heat absorbed in the cooling coil under these conditions was compared to the capacity of heat rejection by the compressor and condenser as stated in the vendor documents to determine whether adequate cooling capacity was provided.

3.2 SYSTEM AIR FLOW RATES

The control room Certified Air Balance Test Report (Certificate No. 112068 of August 25, 1982) performed by PG&E was reviewed, and the recorded values were compared to design air flow rates as shown in the PG&E Flow Diagram (Drawing No. 511157, Revision 6) and duct drawings. Fans' static pressures and motor brake horsepowers recorded in the Certified Air Balance Test Report were compared against the nameplate ratings to determine whether they can accommodate additional system resistances due to dirty filters. Air flow rates taken from the Certified Air Balance Test Report were used to calculate independently the resulting control room temperatures in Section 3.1. This calculation was used to determine whether adequate air is

supplied to the control room to maintain air temperatures at the design values identified in the FSAR Section 9.4.1. The air distribution from the Certified Balance Test Report was compared against the design flows on the Flow Diagram (PG&E Drawing No. 511157, Revision 6). This was done to determine whether the system can be balanced as designed and whether the actual intake and recirculation air flow rates match those values used in the PG&E control room habitability analyses.

In addition, the results of PG&E Startup Test Procedure (No. 23.1, Revision 2, of June 11, 1979, and its Addendum No. 2 of December 29, 1981) were reviewed to check the CRVP system's ability to pressurize the control room under Mode 4 operation as stated in the FSAR Section 9.4.1.

3.3 CODES, STANDARDS, AND REGULATORY GUIDES

PG&E purchase order specifications for the CRVP System equipment were reviewed to determine whether the applicable codes, standards, and regulatory guides identified in the FSAR Table 9.4-6 were specified.

3.4 SYSTEM DESIGN TEMPERATURES AND PRESSURES

Duct and equipment design temperatures and pressures as specified in PG&E purchase order specifications were reviewed to ensure their compatibility with the actual pressures developed by the fans. Similarly, the design temperature and pressure of the refrigerant piping and equipment as specified in the PG&E purchase order specifications were compared against those values expected to occur during operation.

3.5 CONTROL ROOM HABITABILITY

The radiation dose calculation (EDS Nuclear Inc., Calculation No. 006) and chlorine concentration calculation (FSAR Section 9.4.1) were reviewed to determine whether the values of air flow rates, control room volume, filter efficiencies, damper closing time, detector response time, and infiltration rate were input into the calculations correctly. These calculations were also reviewed to determine whether the effects of single failure were considered in the calculations.

The HEPA/charcoal filter unit design was reviewed. Filter efficiencies and air flow capacities specified in the PG&E purchase orders specifications were checked for conformance to the licensing commitments (FSAR Table 15.5-30) during Mode 4 operation. In evaluating the filter efficiencies used in the control room habitability analyses, an independent calculation was performed to check the ability of the duct heaters upstream of the filter unit to remove the moisture from the outside air and to maintain its relative humidity at levels identified in Regulatory Guide 1.52.

The chlorine detector and radiation monitor purchase order specifications were reviewed to determine whether the sensitivities and response times specified to the vendors agreed with the design values identified in the FSAR Section 9.4.1.

3.6 TECHNICAL SPECIFICATIONS REVIEW

The Technical Specifications (Section 3/4.7.5) were reviewed to determine whether they meet the guidelines for in-place testing delineated in Regulatory Guide 1.52 and commitments of FSAR Section 16.5.9. This review was also performed to determine whether the Technical Specifications (Section 3/4.7.5) requirements are compatible with the CRVP system design.

3.7 SYSTEM REDUNDANCY (OPERABILITY AND FUNCTIONABILITY)

A review was performed to determine whether the CRVP system redundancy meets single failure criteria consistent with FSAR Section 9.4.1 commitments. This review was performed assuming a design basis accident concurrent with a single failure.

Single failures considered were failure of a vital bus or failure of an individual component, such as filtration train, fan, damper, air-conditioning equipment, or instrumentation. The CRVP system flow diagram and duct drawings identified in Section 3.2 were used as the basis for the review. The emergency electrical power supply to system components was reviewed for two cases: (1) Unit 1 and Unit 2 both operational; (2) Unit 1 only operational. In addition, a review was performed of the CRVP system's operability and functionability. The PG&E Startup Test Procedure (No. 23.1, Revision 2, of June 11, 1979, and its Addendum No. 2 of December 29, 1981) was reviewed to determine whether the system is capable of operation in each of the four

design modes identified in FSAR Section 9.4.1. The startup test procedure was also reviewed to determine whether the system initiates Mode 3 or Mode 4 operation automatically upon each of the signals identified in FSAR Section 9.4.1.

3.8 FIELD INSPECTION

A field inspection of the CRVP System was performed to compare the as-built configuration to the PG&E Flow Diagram (No. 511157, Revision 6) and duct drawings used in the IDVP review. A walkdown of the system was performed. Parameters such as number and sequence of fans, dampers, air-conditioning equipment, duct layout, and location of radiation and chlorine monitors were checked during the walkdown.

SECTION 4

SUMMARY OF REVIEW RESULTS

This section provides a summary of the review results and identifies all concerns raised as a result of this review.

4.1 CONTROL ROOM COOLING LOAD

The total cooling load calculated by SWEC for Modes 1, 2, 3, and 4 operations is approximately 5 percent higher than the value shown in FSAR Table 9.4-7. This value is considered to be within the e pected calculational accuracy. Using the air flow rate from the Certified Air Balance Test Report, the resulting control room temperature was calculated. From this, the heat absorbed in the cooling coil was also calculated. This calculated cooling load is within the nameplate cooling capacity of the compressor and condenser.

4.2 SYSTEM AIR FLOW RATES

The values recorded in the PG&E control room Certified Air Balance Test Report (Certification No. 112068) for supply air, return air, makeup air, and pressurization air under all four design modes of operation are within 10 percent of the design air flow rates indicated on the PG&E Flow Diagram (No. 511157, Revision 6) and duct drawings. SWEC has determined, based on the control room temperature calculation identified in Section 4.1, that a

variation of ±10 percent in the air flow rates of the CRVP System would not affect the system's ability to maintain the control room temperature below the limits delineated in FSAR Section 9.4.1.

The fan brake horsepowers recorded in the Certified Air Balance Test Report were reviewed. For the supply fans, booster fans, and pressurization fans, the recorded brake horsepowers indicate that the nameplate motor ratings are adequate to accommodate system design air flows.

The resulting control room temperature was calculated based on the cooling load calculated in Section 3.1 and the supply air flow recorded in the Certified Air Balance Test Report. This calculated temperature is well below the maximum allowable control room temperature based on instrument limitations identified in FSAR Section 9.4.1.

The air distribution as recorded in the Certified Air Balance Test Report matches the design values on the PG&E Flow Diagram and duct drawings. Also, the actual intake and recirculation air flow rates recorded in the Certified Air Balance Test Report match the air flow rates used in the PG&E control room habitability analyses.

The results of PG&E Startup Test Procedure No. 23.1 were reviewed. The control room pressure recorded under Mode 4 operation was above the 1/8-inch W.G. positive pressure required in FSAR Section 9.4.1.

4.3 CODES, STANDARDS, AND REGULATORY GUIDES

The review of the PG&E purchase order specifications for the CRVP system equipment showed that the applicable codes, standards, and regulatory guides identified in the FSAR Section 9.4.1 have been specified.

4.4 SYSTEM DESIGN TEMPERATURES AND PRESSURES

Review of the PG&E purchase order specifications indicates that the duct and equipment design pressures match those recommended in the 1972 Equipment Volume of the ASHRAE Handbook for the maximum static pressures developed by the fans. The actual fan static pressures as recorded in the Certified Air Balance Test Report (Certificate No. 112068) are within the specified design pressures. In addition, the materials specified are adequate for the range of temperatures the system is expected to experience.

A review of the PG&E Specification No. 8771 for the refrigerant piping system and valves indicates that the pressures and temperatures developed in the refrigerant piping, valves, and fittings by the compressor and condenser are within the specified design values.

4.5 CONTROL ROOM HABITABILITY

A review of the radiation dose calculation performed by EDS Nuclear Inc. (Calculation No. 006) indicates that the values of air flow rates, control room volume, infiltration rate, and filter efficiencies input into the calculation agree with those identified in FSAR Section 9.4.1.

The calculation also takes the effects of single failure into account by assuming that the outside pressurization air flows through only one of the two filter units.

A review of the chlorine concentration calculations (FSAR Section 9.4.1) shows that the values of air flow rates, infiltration rates, and control room volume input into the calculation match those values identified in the FSAR. However, the value of damper closing time used in the calculations was not the same as the value identified in FSAR Section 9.4.1. An independent calculation showed that the chlorine detector response time could also vary from that value used by PG&E under single failure. Therefore, an independent calculation of chlorine concentration was performed using both the value of damper closing time recorded in the PG&E Startup Test Procedure No. 23.1 and the calculated value for chlorine detector response time. This calculated value of chlorine concentration is within the limits of Regulatory Guide 1.52.

The air flow capacity of the HEPA/Charcoal filter unit specified in the PG&E purchase order specifications is equivalent to that value recorded in the Certified Air Balance Test Report, and, thus, meets the IDVP acceptance criteria. Also, the filter efficiencies specified agree with those used in the control room habitability analyses. In evaluating the filter efficiency for methyliodide, a calculation was performed to find the relative humidity of the air entering the filter unit. This calculated value is within the limits of Regulatory Guide 1.52 necessary to allow the efficiency used in the control room habitability analyses.

The PG&E purchase order specifications for chlorine and radiation monitors were also reviewed. The review showed that the specified monitors' sensitivities and response times agree with the values identified in FSAR Section 9.4.1. The duct drawings for the pressurization air intakes and as-built configuration at the normal air intakes were reviewed during a site visit. These reviews showed that the chlorine and radiation monitors have been located as indicated in the FSAR Figure No. 9.4-1.

4.6 TECHNICAL SPECIFICATIONS REVIEW

The requirements for in-place testing of the CRVP System stated in the Technical Specifications (Section No. 3/4.7.5) conform to the guidelines of Regulatory Guide 1.52 and commitments in FSAR Section 16.5.9. In addition, the limiting conditions for plant operation stated in the Technical Specifications allow the CRVP System to perform its design function, assuming single failure except for adequacy of equipment electrical power supplies. The adequacy of electrical power supplies is discussed below.

4.7 SYSTEM REDUNDANCY (OPERABILITY AND FUNCTIONABILITY)

A review of the PG&E Flow Diagram (No. 511157, Revision 6) and duct drawings for the CRVP System shows that the design of the CRVP System does include redundant equipment. However, a review of the emergency electric power supplies shows that adequate electrical power redundancy is not supplied to the CRVP System to meet the single failure criteria identified in FSAR

Section 9.4.1. The concern exists that portions of the CRVP System required to maintain the Unit 1 control room habitability are shared between Units 1 and 2 and, as such, are provided safety-related power from the Unit 2 diesel generators and electrical system. If the Unit 2 safety-related electrical system is not available, the CRVP System does not meet the single failure criteria. Typical examples are given below:

- With only Unit 1 power available, there 's no power available for the radiation and chlorine monitors located in the pressurization system south remote air intake.

- Failure of "H" Bus would result in no power available for the Unit 1 air-conditioning equipment, which provides conditioned air to remove heat generated from the vital electrical equipment located in the safeguards room.

- Failure of "H" or "F" Bus would result in no power available for the normal air intake and exhaust motor-operated dampers which are required to close and to isolate the control room envelope from the outside contaminated air during a loss-of-coolant accident (LOCA) and to permit control room pressurization.

PG&E has provided a resolution for this concern consisting of physical modifications to the CRVP System. These changes provide each equipment train with both a Unit 1 and Unit 2 power supply. Redundant trains are

powered from different vital buses. An independent failure analysis was performed for Unit 1 operation assuming all trains are switched to their Unit 1 vital bus. The results of this analysis show that the modified system design can meet the FSAR single failure criteria.

Another concern is that portions of the Class 1 CRVP System are shared by Unit 1 and Unit 2, and, as such, equipment is provided electrical power from both the Units 1 and 2 safety-related electrical system. The FSAR states that for a postulated LOCA in one unit the other unit must be shut down. Further, Page 8.3-4 states that each unit is designed to withstand an assumed failure of a vital bus. It is required to assume that offsite power is lost coincident with the LOCA; therefore, it must be assumed that three vital buses (one in the LOCA unit and two in the unit performing a shutdown) do not have power available. Evaluation of the various combinations of vital bus failures for a postulated LOCA in either Unit 1 or Unit 2 identifies conditions under which the CRVP System does not meet its design bases as stated in licensing commitments. Typical examples are provided below:

- LOCA in Unit 2

  Combinations of Vital Bus Failures: F2 H1 H2

  F1 F2 H2

  F2 G2 H1

  No power available to any of the above combinations of vital buses would prevent the automatic closure of the outside air normal

intake and exhaust motor-operated dampers. These dampers are required to close in Mode 4 operation to permit control room pressurization to 1/8-inch W.G. and reduce radioactivity inleakage. Also, no power to vital bus combinations F2, H1, H2 and F2, G2, H1 would result in loss of power to the air-conditioning units which provide cooling to the safeguards room which contains the vital electrical equipment required for safe shutdown.

- LOCA in Unit 2

  Combinations of Vital Bus Failures: F1 G1 H2
  F1 H1 H2
  F1 F2 H1

  No power available to any of the above vital bus combinations would prevent the automatic closure of the outside air normal intake and exhaust motor-operated dampers. These dampers are required to close in Mode 4 operation to permit control room pressurization to 1/8-inch W.G. and reduce radioactivity inleakage. Also, no power to vital bus combinations F1, G1, H2 and F1, H1, H2 would result in loss of power to the air-conditioning units which provide cooling to the safeguards room, which contains the vital electrical equipment required for safe shutdown.

The modifications to the CRVP System proposed by the DCP will alleviate the concern of not meeting single failure criteria and will provide adequate electrical power redundancy for the CRVP System.

The Preoperational Test Procedure No. 23.1 performed by PG&E on the CRVP System was reviewed. The test procedure indicated that the system did switch to, and operate in, each of the four design modes of operation identified in the FSAR upon manual initiation. Also, the report indicated that the system did automatically initiate Mode 3 or Mode 4 operation upon simulating each of the initiation signals identified in the FSAR.

4.8 FIELD INSPECTION

A complete walkdown of the CRVP System was performed. Those parameters identified in Section 3.8 were found to be in accordance with the PG&E Flow Diagram (No. 511157, Revision 6) and duct drawings.

SECTION 5

EOI REPORTS ISSUED

Two EOI files were issued for the verification of mechanical/nuclear design of the CRVP System. The status of these files is summarized in Appendix A.

EOI File 8012 was issued because of the concern for lack of electrical power redundancy to provide adequate cooling and pressurization for the control room if Unit 2 power supplies are not available. PG&E has reevaluated the system electrical redundancy and has provided a resolution involving physical modifications. These modifications provide the capability to meet the single failure criteria. This file remains open as an Error Class A pending IDVP verification of the modifications.

EOI File 8016 was issued because of the concern for lack of redundancy to provide adequate cooling and pressurization for the control room with both Units 1 and 2 available. The modifications made in response to EOI File 8012 also provide the capability for the CRVP System to meet the single failure criteria for two-unit operation; therefore, no other modifications are necessary. This file has been closed.

SECTION 6

EVALUATION OF REVIEW RESULTS

6.1 CONTROL ROOM COOLING LOAD

The cooling capacity of the CRVP system air-conditioning equipment identified in the FSAR is adequate for the calculated maximum cooling load and, thus, meets the IDVP acceptance criteria.

6.2 SYSTEM AIR FLOW RATES

The air flow rates recorded for the control room in the Certified Air Balance Test Report agree with those values identified in the PG&E Flow Diagram and duct drawings and, thus, meet the IDVP acceptance criteria.

The calculated control room temperature is below the upper limit based on instrument limitations identified in the FSAR and, thus, meets the IDVP acceptance criteria.

6.3 CODES, STANDARDS, AND REGULATORY GUIDES

The codes, standards, and regulatory guides specified in the PG&E purchase specifications agree with those listed in the FSAR and, thus, meet the IDVP acceptance criteria.

6.4 SYSTEM DESIGN TEMPERATURES AND PRESSURES

The specified materials of construction for the CRVP System are adequate for the static pressures recorded for the control room in the Certified Air Balance Test Report and the temperatures identified in the FSAR. The expected operational pressures and temperatures are within the specified design values; therefore, the IDVP acceptance criteria are met.

6.5 CONTROL ROOM HABITABILITY

The parameters reviewed for the control room habitability analyses agree with those identified in the FSAR and, thus, meet the IDVP acceptance criteria.

6.6 TECHNICAL SPECIFICATIONS REVIEW

The review of the Technical Specifications showed that the CRVP system design as described in the FSAR is compatible with the requirements of the technical specifications; therefore, the IDVP acceptance criteria are met.

6.7 SYSTEM REDUNDANCY (OPERABILITY AND FUNCTIONABILITY)

The mechanical equipment redundancy and the system operability and functionability meet the acceptance criteria of the IDVP. However, the original emergency electrical power arrangement did not meet the IDVP acceptance

criteria for single failure. The major deficiencies in the emergency electrical power redundancy arose because some safety-related Unit 1 equipment was powered only from Unit 2 power supplies and, conversely, some safety-related Unit 2 equipment was powered only from Unit 1 power supplies. The physical modifications proposed by PG&E will provide the capability to meet the single failure criteria. These modifications will be field-verified by the IDVP. The generic concern for shared power sources is discussed in ITR No. 34.

6.8 FIELD INSPECTION

The as-built configuration of the CRVP System for those parameters identified in Section 3.8 agrees with the configuration identified in the FSAR and design documents and, thus, meets the acceptance criteria of the IDVP.

SECTION 7

CONCLUSIONS

The following sections summarize whether additional verification or additional sampling of the items reviewed is required.

7.1 CONTROL ROOM COOLING LOAD

No additional verification or additional sampling is needed.

7.2 SYSTEM AIR FLOW RATES

No additional verification or additional sampling is needed.

7.3 CODES, STANDARDS, AND REGULATORY GUIDES

No additional verification or additional sampling is needed.

7.4 SYSTEM DESIGN TEMPERATURES AND PRESSURES

No additional verification or additional sampling is needed.

7.5 CONTROL ROOM HABITABILITY

No additional verification or additional sampling is needed.

7.6 TECHNICAL SPECIFICATIONS REVIEW

No additional verification or additional sampling is needed.

7.7 SYSTEM REDUNDANCY (OPERABILITY AND FUNCTIONABILITY)

Since there is evidence of a generic concern in the design of shared systems (between Units 1 and 2), additional verification, as discussed in ITR No. 34, of the emergency electrical power supplies of shared systems is required.

7.8 FIELD INSPECTION

No additional verification or additional sampling is needed.

APPENDIX A

EOI FILES

APPENDIX A

DCNPP IDVP STATUS REPORT

	REV. 0	LATEST REV.				ACTION	
FILE NO.	DATE	REV.	DATE	BY	STATUS	ORG	SUBJECT
8012	820924	0	820924	SWEC	OIR	SWEC	CLASS 1 PORTIONS OF CRVP SYSTEM
8012	820924	1	821001	SWEC	PPRR/OIP	TES	CLASS 1 PORTIONS OF CRVP SYSTEM
8012	820924	2	821022	TES	OIR	SWEC	CLASS 1 PORTIONS OF CRVP SYSTEM
8012	820924	3	821103	SWEC	PER/A	TES	CLASS 1 PORTIONS OF CRVP SYSTEM
8012	820924	4	821116	TES	ER/A	PG&E	CLASS 1 PORTIONS OF CRVP SYSTEM
8012	820924	5	830311	TES	OIR	SWEC	CLASS 1 PORTIONS OF CRVP SYSTEM
8012	820924	6	830311	SWEC	PER/A	TES	CLASS 1 PORTIONS OF CRVP SYSTEM
8012	820924	7	830315	TES	ER/A	PG&E	CLASS 1 PORTIONS OF CRVP SYSTEM
8016	820927	0	20927	SWEC	OIR	SWEC	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	1	821001	SWEC	PPRR/OIP	TES	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	2	821022	TES	OIR	SWEC	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	3	821103	SWEC	PER/A	TES	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	4	821116	TES	ER/A	PG&E	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	5	830225	TES	OIR	SWEC	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	6	830310	SWEC	PER/B	TES	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	7	830328	TES	PRR/OIP	PG&E	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	8	830328	TES	PRR/CI	PG&E	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS
8016	820927	9	830328	TES	CR	NONE	CL.1 PORTIONS OF CRVP SYS. NOT MEETING DES. BASIS

APPENDIX B

PROGRAM MANAGER'S ASSESSMENT

APPENDIX B

PROGRAM MANAGER'S ASSESSMENT

Independent design verification of the tasks performed by SWEC to verify the Mechanical/Nuclear Design of the CRVP System was done in accordance with the IDVP Phase II Program Management Plan, dated June 18, 1982 and the Engineering Procedure EP-1-014.

The task of verification involved several visits to the SWEC offices and detailed discussion and review with SWEC personnel of the work performed by SWEC including the methodology and calculations used in this evaluation.

The files issued by SWEC were reviewed thoroughly and specific recommendations were made to the IDVP Program Manager delineating appropriate resolution.

As a result of the verification of the initial sample by SWEC and the assessment of the impact of SWEC findings, TES, as Program Manager is of the opinion that because of the concern of shared power sources, additional verification is required.

ROBERT L. CLOUD ASSOCIATES, INC.
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BERKELEY, CALIFORNIA 94710
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P105-4

April 29, 1983

Mr. G. H. Maneatis, Executive Vice President
Facilities and Electric Resources Development
Pacific Gas and Electric Company
77 Beale Street
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Mr. H. R. Denton, Director
Office of Nuclear Reactor Regulation
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Mr. J. B. Martin, Regional Administrator
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U. S. Nuclear Regulatory Commission
1450 Maria Lane, Suite 210
Walnut Creek, CA 94596

Docket Nos. 50-275
Diablo Canyon Unit 1
License No. DPR-76

Gentlemen:

Enclosed please find Interim Technical Report No. 33, Revision 1 on Electrical Equipment Analysis issued by Robert L. Cloud and Associates for the Independent Design Verification Program, (P105-4-839-033).

This Interim Technical Report has been revised to include the additional verification results as shown by the side bars.

Yours truly,

Edward Denison

Edward Denison

ED:mk

Enclosure

cc: R. Fray
R. Reedy
F. Sestak
W. Cooper
H. Schierling ✓
R. Hubbard
M. Strumwasser
D. Fleischaker
J. Reynolds/J. Phillips
B. Norton
A. Gehr
J. Roesset

Dupe PDR ~~8305030573~~

Robert L. Cloud and Associates, Inc.

RLCA

Interim Technical Report

DIABLO CANYON UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM
ELECTRICAL EQUIPMENT ANALYSIS
ITR #33
REVISION 1

Robert L. Cloud and Associates, Inc.

RLCA

Interim Technical Report

DIABLO CANYON UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM
ELECTRICAL EQUIPMENT ANALYSIS
ITR #33
REVISION 1

Docket No. 50-275
License No. DPR-76

[signature] 4/28/83
Project Engineer/Date
Technical Review

Edward Denison 4/28/83
Project Manager/Date
Approved P 105-4-839-033

Dupe PDR ~~8305030581~~

TELEDYNE ENGINEERING SERVICES

PROGRAM MANAGER'S PREFACE

DIABLO CANYON NUCLEAR POWER PLANT - UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT

ELECTRICAL EQUIPMENT BY ANALYSIS

This is Revision 1 to the thirty-third of a series of Interim Technical Reports prepared by the DCNPP-IDVP for the purpose of providing a conclusion of the program.

The original issue of this report contained the analytical methods and results of the independent analyses, the concerns, recommendations, and conclusions of the IDVP with respect to the initial sample for electrical equipment qualified by analysis. This revision contains, along with the initial sample results in the original report, the results of the additional verification effort. All EOI files initiated for this sample category, both in the initial sample and additional verification evaluations, have been closed or identified as an error.

As IDVP Program Manager, Teledyne Engineering Services has approved this Revision 1 to ITR-33, including the conclusions and recommendations presented. The methodology followed by TES in performing this review and evaluation is described in Appendix D to this report.

ITR Reviewed and Approved
IDVP Program Manager
Teledyne Engineering Services

R Wray

R. Wray
Assistant Project Manager

ELECTRICAL EQUIPMENT ANALYSIS

REVISION 1

Contents

Page No.

ELECTRICAL EQUIPMENT ANALYSIS

List of Tables

ELECTRICAL EQUIPMENT ANALYSIS

List of Figures

1.0 INTRODUCTION

Purpose and Scope

This interim technical report summarizes the independent analysis and verification of the initial sample of electrical equipment qualified by analysis at Diablo Canyon Nuclear Power Plant Unit 1 (DCNPP-1). The electrical equipment sample consists of the hot shutdown remote control cabinet and the main annunciator cabinet.

In addition, this report summarizes the verification of the natural frequencies for an additional sample of electrical equipment qualified by analysis at DCNPP-1. The sample consists of the local instrument panels and the instrument AC panels.

Verification and specification of additional samples is described in the Interim Technical Report (ITR) #1, Revision 1 (Reference 1). The IDVP determined that instrument panels PIA, B and C, though specified in ITR #1, Revision 1, were analyzed by the manufacturer, and thus were not part of the IDVP review scope.

This report is one of several interim technical reports of the Independent Design Verification Program (IDVP). Interim technical reports include references, sample definitions and descriptions, methodology, a listing of Error and Open Items, and examination of trends and concerns, and a conclusion (Reference 2). This report presents the results of the IDVP electrical equipment analysis and serves as a vehicle for NRC review. It will also be referenced in the Phase I Final Report.

This report does not include the independent verification of Class 1E electrical components which are mounted to the hot shutdown remote control cabinet or main annunciator cabinet. These items were qualified by shake table testing. The verification of the electrical equipment qualified by shake table testing is the subject of a separate interim technical report (Reference 3).

Also not included here is the verification of Class 1E electrical components mounted to local instrument panels or instrument AC panels. These items were qualified separately.

Summary

Robert L. Cloud and Associates Inc. (RLCA) has performed verification analyses for the Phase I initial sample of electrical equipment qualified by analysis. Loads and stresses were calculated and compared to allowables. Methods and assumptions used in the design analyses were compared to those in the verification analyses. Allowable criteria were met for the hot shutdown remote control cabinet, but were exceeded for the main annunciator cabinet assembly. A generic concern with regard to frequency assumptions was identified and recommendations were made.

As a result of the initial sample comparison, the IDVP reviewed natural frequency assumptions for an additional sample of electrical equipment qualified by analysis. An error was identified in the design natural frequency calculations. However, both the local instrument panels and instrument AC panels were found to meet the frequency criteria for rigid equipment.

Background

On September 28, 1981 PGandE reported that a diagram error had been found in a portion of the seismic qualification of the Diablo Canyon Nuclear Power Plant Unit 1. This error resulted in an incorrect application of the seismic floor response spectra for sections of the annulus of the Unit 1 containment building. The error originated when PGandE transmitted a sketch of Unit 2 to a seismic service-related contractor. This sketch contained geometry incorrectly identified as Unit 1 geometry.

As a result of this error, a seismic reverification program was established to determine if the seismic qualification of the plant was adequate for the postulated Hosgri 7.5M earthquake. This program was presented orally to the NRC in a meeting in Bethesda, Maryland on October 9, 1981.

Robert L. Cloud and Associates (RLCA) presented a preliminary report on the seismic reverification program to the NRC on November 12, 1981 (Reference 4). This report dealt with an examination of the interface between URS/Blume and PGandE.

The NRC commissioners met during the week of November 16, 1981 to review the preliminary report and the overall situation. On November 19, 1981 an Order Suspending License CLI-81-30 was issued which suspended PGandE's license to load fuel and conduct low power tests up to 5% of rated power at DCNPP-1. This suspending order also specified that an independent design verification program be conducted to ensure that the plant met the licensing criteria.

PGandE retained Robert L. Cloud and Associates as program manager to develop and implement a program that would address the concerns cited in the order suspending license CLI-81-30. The Phase I Plan for this program was tranmitted to the NRC staff in December 1981 and discussed on February 1, 1982. Phase I deals with PGandE internal activities and seismic service-related contractors prior to June 1978.

On March 19, 1982 the NRC approved Teledyne Engineering Services (TES) as program manager to replace Robert L. Cloud and Associates (RLCA). However, RLCA continued to perform the independent review of seismic, structural and mechanical aspects of Phase I.

The NRC approved the Independent Design Verification Program Phase I Engineering Program Plan on April 27, 1982. This plan dictates that a sample of piping, equipment, structures and components be selected for independent analysis. The results of these analyses are to be compared to the design analyses results. If the acceptance criteria is exceeded, an Open Item Report is to be filed. Interim technical reports are to be issued to explain the progress of different segments of the technical work.

ITR #33, Revision 0 was issued in February, 1983 to describe the IDVP verification of an initial sample of electrical equipment qualified by analysis. Two concerns were noted and recommendations were made for additional verification. Results and conclusions of this additional verification are reported in Section 5 of this ITR.

2.0 INDEPENDENT DESIGN VERIFICATION METHODS

2.1 PROCEDURES

The verification analysis used the following procedures to analyze the seismic qualification of the hot shutdown remote control cabinet and main annunciator cabinet.

First, the equipment's physical dimensions were verified in the field. Next, the equipment was mathematically modeled to represent the equipment's mass and stiffness characteristics. From this model, natural frequencies were determined. Applicable seismic accelerations were obtained using the natural frequencies together with the appropriate Hosgri response spectra. Forces and moments were calculated for the key areas. Stresses were determined from the forces and moments. These computed stresses were compared to the allowable stresses. Finally, the stresses computed by the IDVP were compared to the stresses from the design analysis.

2.2 LICENSING CRITERIA

The IDVP used the Diablo Canyon Nuclear Power Plant Unit 1 licensing criteria to analyze the hot shutdown remote control cabinet and the main annunciator cabinet assembly. This criteria is contained in the FSAR and the Hosgri Report (References 5 and 6).

Allowable criteria have been taken from the "Steel Construction Handbook, Seventh Edition" (Reference 7). Allowable criteria for concrete expansion anchors have been taken from PGandE Drawing 054162, Revision 3, "Concrete Expansion Anchors for Seismic and Static Loading," (Reference 8). Loading combinations are also included in Attachment 1 of the Phase I Engineering Program Plan (Reference 9).

3.0 VERIFICATION ANALYSIS OF ELECTRICAL EQUIPMENT

3.1 HOT SHUTDOWN REMOTE CONTROL CABINET

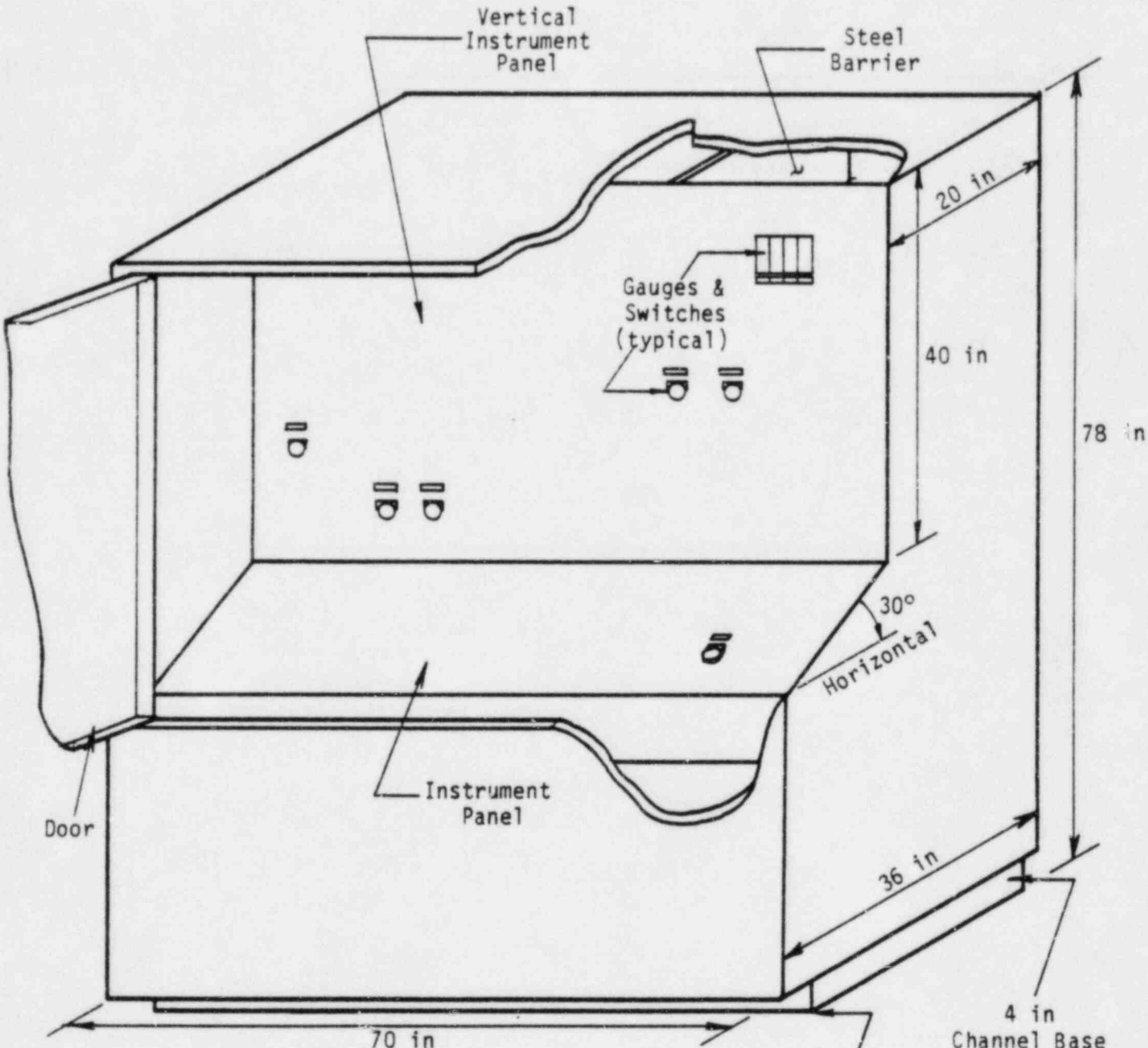
The hot shutdown remote control cabinet (called a panel in the Hosgri Report) is located at the West end of the Unit 1 auxiliary building at elevation 100 feet. The cabinet contains indicators and manual controls for various pumps and valves in the auxiliary feedwater, boration control, and containment fan cooler systems.

The hot shutdown remote control cabinet is designed to act as backup to the control room instrumentation and controls and allows the plant to be brought to a hot shutdown condition. The overall cabinet configuration is shown in Figure 1. Figure 2 shows the cabinet base and support details.

The cabinet is made of 11 gauge steel. Its dimensions are approximately 5 feet 10 inches wide, 6 feet 6 inches high, and 3 feet deep. The cabinet is oriented such that front-to-back corresponds to the East-West direction. The front of the cabinet has doors which enclose the 3/16 inch thick steel instrument panels, one vertical and the other diagonal, tilted at 30 degrees up from the horizontal. Instruments and switches are mounted on both panels (see Figure 1). Steel separation barriers are welded to the back of the panels to isolate va[illegible]us instruments. The rear of the cabinet has doors which provide service access to wiring and instrumentation.

A vertical 11 gauge sheet metal barrier running the full height and depth of the cabinet laterally separates the interior of the cabinet. This barrier is also shown in Figure 1.

The cabinet is mounted on four steel 4 inch channels which are welded to a box comprised of 10 inch I-beams. This box, in turn, is bolted to steel plates embedded in the concrete floor.



Oblique Front View
Including Cut-Out

Figure 1

Hot Shutdown Remote Control Cabinet
Overall Configuration

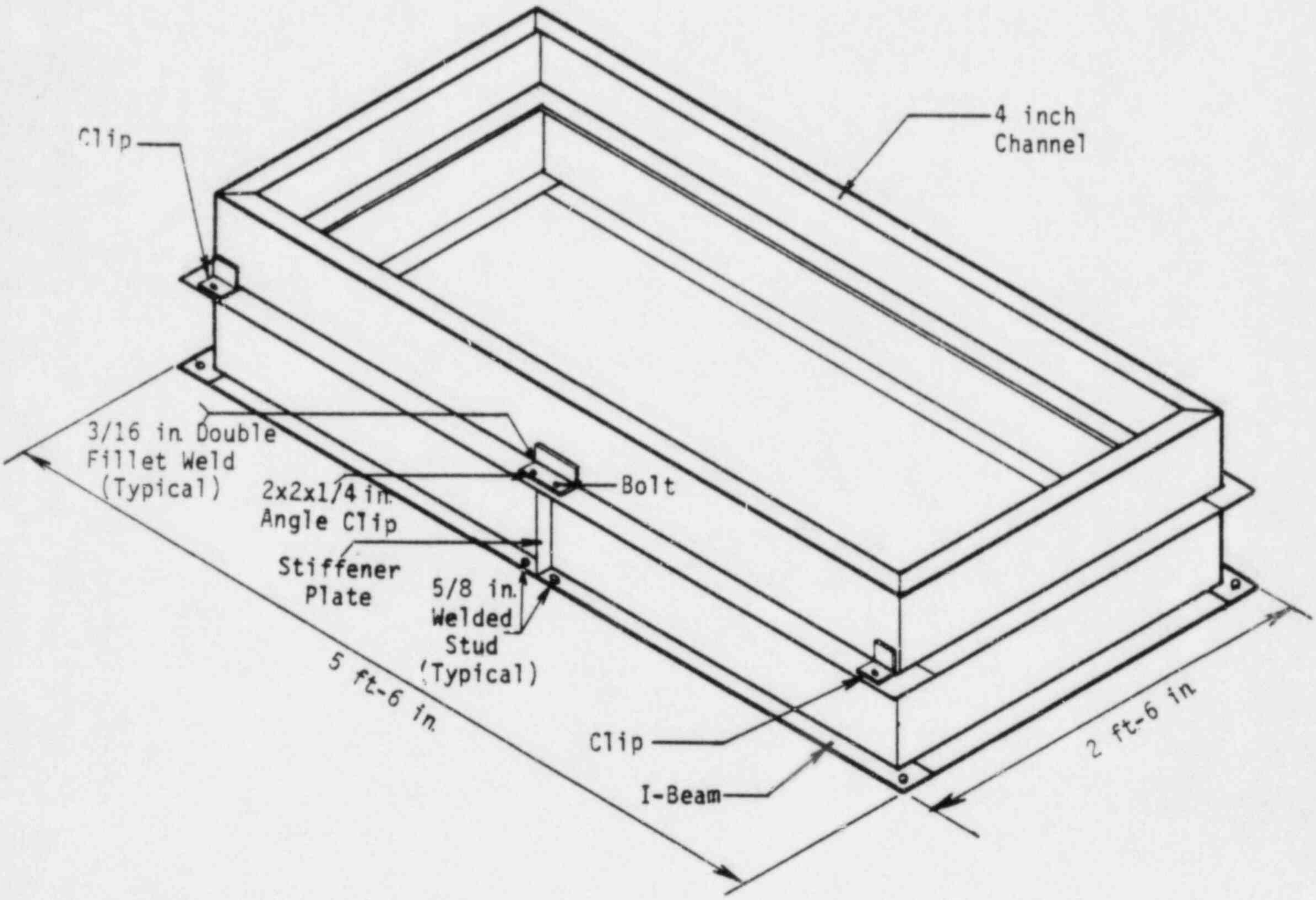


Figure 2

Hot Shutdown Remote Control Cabinet Support

3.1.1 Method of Verification Analysis

Overall Structure Characteristics

After field verifying the dimensions of the hot shutdown remote control cabinet and its supporting structure, the IDVP developed a mathematical model to simulate the equipment's mass and stiffness characteristics. Overall cabinet stiffnesses in the horizontal direction were calculated for bending and shear (Reference 10).

These stiffnesses were calculated for a reduced cross-section of the cabinet structure. Instead of considering the full 36 inch depth of the cabinet in the front-to-back direction, stiffnesses were calculated for the 20 inch section of cabinet equivalent to the section of upper cabinet above the diagonal panel (see Figure 1). In addition, the model neglected shear stiffness contribution of the interior steel barrier and any stiffness contribution in this direction from the doors.

The stiffnesses were used to develop a single degree of freedom lump mass model to represent overall cabinet dynamic characteristics. The complete cabinet mass was lumped at the center of gravity. This model is more flexible than the actual case, and hence, is conservative because it would yield lower natural frequencies and a larger response. This model was used to determine the front-to-back horizontal natural frequencies.

The IDVP examined the cabinet's configuration and determined that the model of the cabinet in the front-to-back direction represented the most flexible direction. Because the natural frequency in this direction was found to be greater than 33 hertz, the IDVP concluded that overall cabinet was rigid.

Hosgri response spectra for 4% damping and natural frequency results were used to determine seismic accelerations (Reference 6). Torsional accelerations of the auxiliary building were included. The value of damping used, however, is irrelevant because the cabinet was rigid ($\geq$ 33 hertz) and zero period accelerations were used. The spectra considered in the verification analysis are listed in Appendix C. The following seismic accelerations were used:

.76 g	Horizontal	East-West
.97 g	Horizontal	North-South
.60 g	Vertical	

These accelerations were used to calculate the loads and forces at key areas (see Table 1). Using these forces and loads, stresses at key areas were calculated and then compared to allowable stresses.

<u>Local Dynamic Characteristics</u>

To analyze the cabinet in greater detail, the IDVP created a finite element computer model to examine the local dynamic characteristics of the cabinet's two instrument panels. Using plate elements, a STARDYNE finite element model was developed for the two instrument panels. The model took into consideration instrument cutouts, major instrument weights, and the welded separation barriers. The configuration of the model is shown in Figure 3. The weights of the instruments were lumped at the node points corresponding to the instrument locations. The total weight of instrumentation included in the model was approximately 167 pounds.

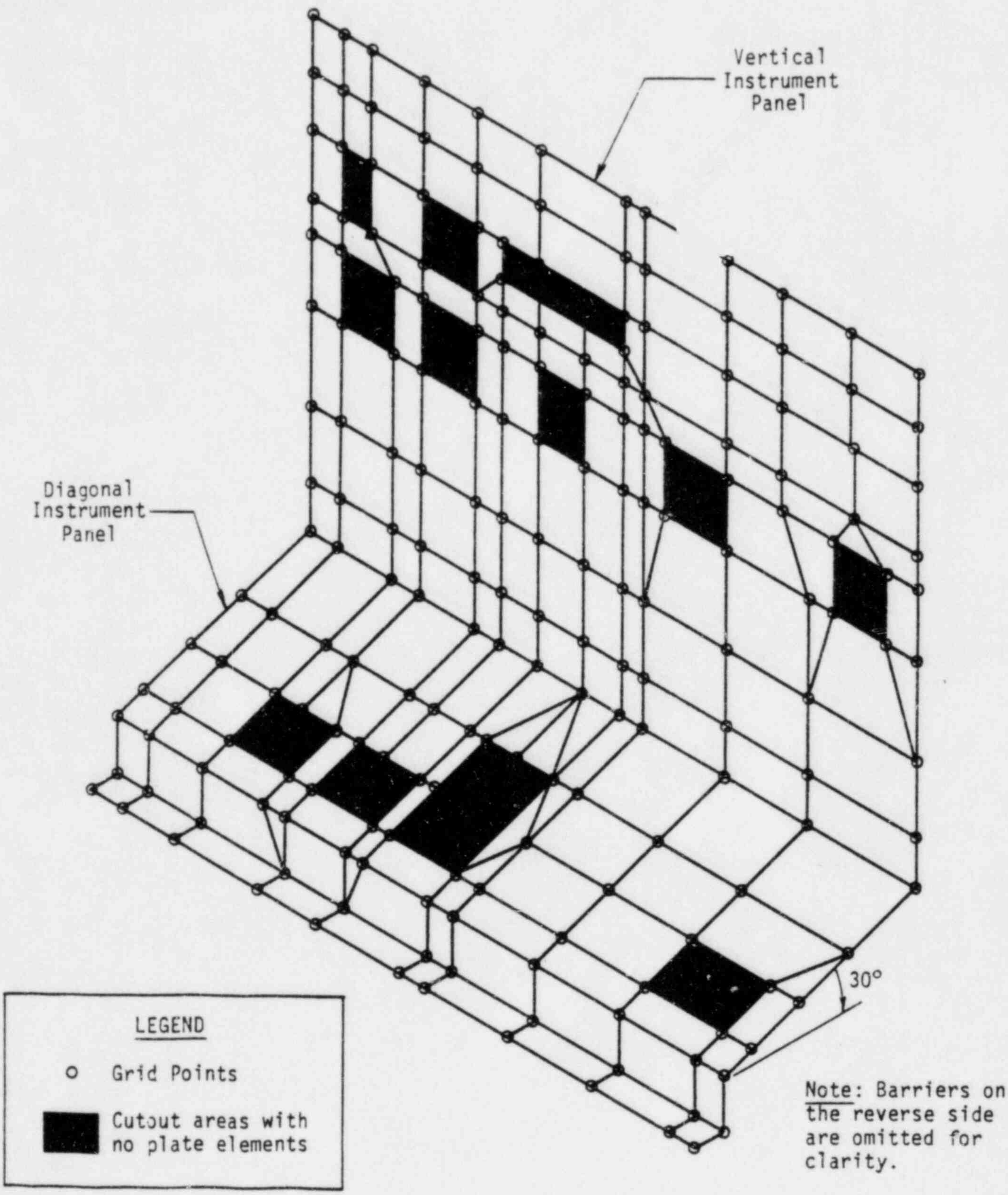


Figure 3

STARDYNE Model of Instrument Panels in
Hot Shutdown Remote Control Cabinet

The 3/16 inch steel instrument panel is intermittently fillet welded to 3 x 2 x 1/4 inch and 2 x 2 x 1/4 inch angles along the perimeter and is tack welded to the 11 gauge interior barrier along the length of the barrier. The verification analysis accounted for these attachment configurations by using two separate computer models to bound the analysis. The first model assumed the local panel edges to be simply supported, i.e., no moment resistance at the edges. The second model assumed the edges to have a fixed boundary condition, i.e., the edge support does have moment resistance capability.

Instrument panel frequencies were calculated from the finite element model, and a computer response spectrum analysis was performed to determine the accelerations, loads and stresses. Hosgri response spectra for 4% damping, were applied at the edges in the model representing the panel attachment to the cabinet. Although Hosgri response spectra apply to floor mounted equipment, they also apply to these panels because the cabinet to which they are attached is rigid, ($\geq$ 33 hertz) in all directions.

Calculated stresses were then compared to the allowables.

3.1.2 Results of Verification Analysis

The IDVP computed stresses at the following key areas and compared them to the allowable stresses (see Table 1). Both the stresses for the cabinet and those stresses due to local dynamic characteristics of the instrument panel are presented.

Hot Shutdown Remote Control Cabinet	Computed	Allowable
Key Areas		
Overall Cabinet		
Cabinet base angle to base channel bolt stress		
Tension*	1,113 psi	20,000 psi
Shear	457 psi	10,000 psi
Cabinet base angle stress	12,288 psi	22,000 psi
Base channel to I-beam weld stress*	1,088 psi	21,000 psi
Angle clip at I-beam tensile stress		
Axial	427 psi	(only combined
Bending*	9,984 psi	stress compared)
Combined	10,411 psi	22,000 psi
Clip to I-beam bolt stress		
Tension	2,591 psi	20,000 psi
Shear	687 psi	10,000 psi
I-beam anchor bolt stress		
Tension*	10,792 psi	20,000 psi
Shear	687 psi	10,000 psi
Cabinet sheet metal stress	10,800 psi	22,000 psi
Side panel buckling load	1,260 lb.	11,737 lb.
Local Dynamic Characteristics of Two Instrument Panels		
Maximum combined panel stress	2,546 psi	22,000 psi

*Note: Those stresses marked with an asterisk show those key areas which are also explicitly evaluated in the design analysis.

Table 1
Comparison of Computed and Allowable Loads and Stresses in the Hot Shutdown Remote Control Cabinet

A comparison of the computed stresses for the key areas to the allowable stresses shows that the hot shutdown remote control cabinet meets the allowable criteria.

The natural frequency results from the bounding local panel analyses showed the model with simply supported edges has a first natural frequency in the flexible range, and the model with fixed edges has a first natural frequency in the rigid range. These frequencies are given below:

Simply supported edges	26.5 hertz
Fixed edges	42.7 hertz

The local panel was judged to be rigid because the actual panel edge boundary conditions are between fixed and simply supported edges, and the intermittently fillet welded edges are more similar to the fixed edge boundary condition.

3.1.3 Design Analysis Methods

The design analysis examined the front to back vibrational frequencies using a lump mass model with nine dynamic degrees of freedom (as shown in Figure 4). The side-to-side and vertical natural frequencies were determined by inspection to be greater than those for the front-to-back direction, based on the fact that the doors are closed during normal plant operation (Reference 11).

The design analysis calculated loads and stresses using a one mode response spectrum analysis. Key areas were examined for shear and overturning moment loadings. Three key area stresses were reported for the hot shutdown remote control cabinet (shown in Section 3.1.5).

3.1.4 Comparison of Verification and Design Analysis Methods

Both the verification and design analyses of the overall cabinet structure considered the cabinet's front-to-back direction to be the most flexible direction. However, the methodologies used to represent the front-to-back charateristics differed: while the verification analysis used a single degree of freedom model based on a reduced cross-section of the cabinet, the design analysis used a lump mass and beam element model with nine lumped masses.

Both the verification and design analyses found the lowest natural frequency to be in the rigid range. Based on this result, both analyses concluded that the cabinet natural frequencies in side-to-side and vertical directions were rigid.

The verification analysis also examined the local instrument panel.

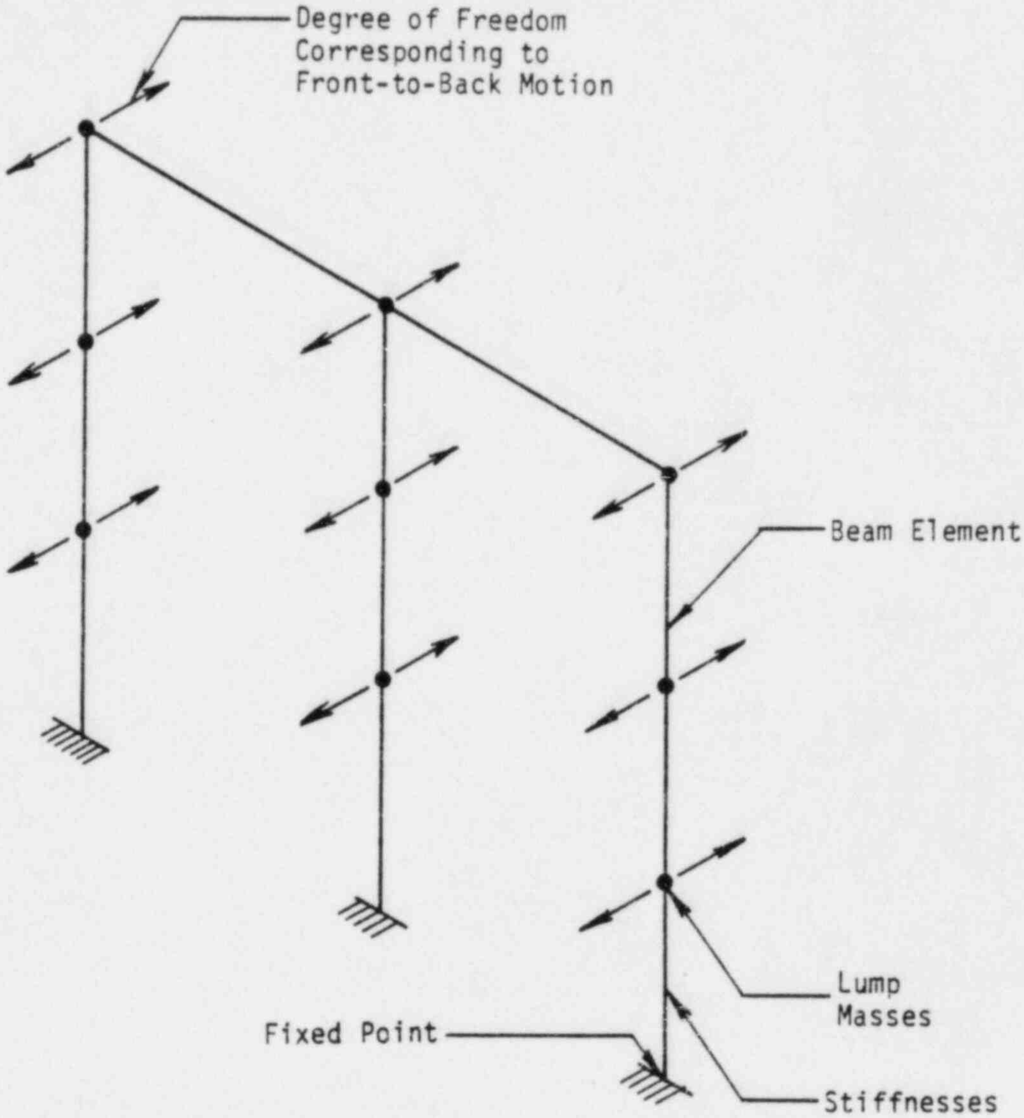


Figure 4

Design Analysis Dynamic Model For
Hot Shutdown Remote Control Cabinet

3.1.5 Comparison of Verification and Design Analysis Results

The IDVP compared the results of their independent analysis listed in Section 3.1.2 with the results of the design analysis as follows:

	Verification Analysis	Design Analysis
Cabinet base angle to channel bolt tensile stress	1,113 psi	440 psi
Angle clip at I-beam bending stress	9,984 psi	8,000 psi
I-Beam anchor bolt tensile stress	2,482 lbs.	520 lbs.

Table 2

Comparison of Verification and Design Analysis Stresses for the Hot Shutdown Remote Control Cabinet

Both the verification and design analysis stress results are lower than the allowable stresses. Although different methods and assumptions were used, both analyses produced similar results.

The verification analysis used a single degree of freedom model using a stiffness calculated from a reduced cross section. The total mass of the cabinet was lumped at the center of gravity. The design analysis used a more refined model with nine distributed lump masses.

3.1.6 Error and Open Item Reports

The IDVP issued one EOI report specifically for the hot shutdown remote control cabinet. Table A-1 shows the EOI file number, revision, date, and status.

EOI 1087 reports differences of greater than 15% between the independent analysis results and the design analysis results. This EOI was subsequently closed because the IDVP showed all stresses to be below the allowable stresses.

The IDVP issued three other EOI's not dealing specifically with the hot shutdown cabinet, but as a result of the RLCA Preliminary Report, "Seismic Reverification Program," dated November 12, 1981 (Reference 4).

EOI 1004 was issued because insufficient documentation was available to verify the transmittal of seismic information across the PGandE and the NSSS (Nuclear Steam Supply System) supplier. The IDVP has verified this interface through a review of correspondence and an audit of the NSSS supplier. This work is reported in IDVP Interim Technical Report #11, Revision 0 (Reference 12). EOI 1004 was resolved as a closed item.

EOI 1006 was issued because insufficient documentation was available to verify the interface between PGandE and the groups performing electrical equipment analysis. EOI 1006 was subsequently closed because the IDVP sample analyses verify the technical adequacy of the electrical equipment analyses without examination of the original interface.

EOI 1007 was issued because available records did not adequately document the transfer of seismic information between PGandE and their service-related contractors. EOI 1007 was subsequently closed because the IDVP sample analyses verify the technical adequacy of the electrical equipment analyses without examination of the original interface.

3.2 MAIN ANNUNCIATOR CABINET

The main annunciator cabinet is an integrated assembly comprised of nine separate cabinets housing various electrical components of the main annunciator system (see Figure 5). The cabinet is located on elevation 127 feet in the auxiliary building below the control room in the cable spreading area. The main annunciator system is used to sound alarms and light indicator lamps in the main control room to signal the plant operator.

Each of the nine structurally identical cabinets is constructed of 12 gauge formed members and sheet metal. They have doors in the front and rear which open to allow access to the components mounted within. These doors run the full length and width of each cabinet and close out-of-plane from the cabinet structure (as opposed to flush with the structure). The components are mounted on internal racks. Figure 5 shows the general configuration of the cabinet assembly.

The base of the cabinet assembly is welded to steel plates embedded in the floor slab, and has a truss-type brace tying the top of the cabinet assembly to an adjacent concrete wall. The brace is attached to the top of each cabinet through two steel channels which run the full length of the cabinet assembly. Details of this brace are shown in Figure 6.

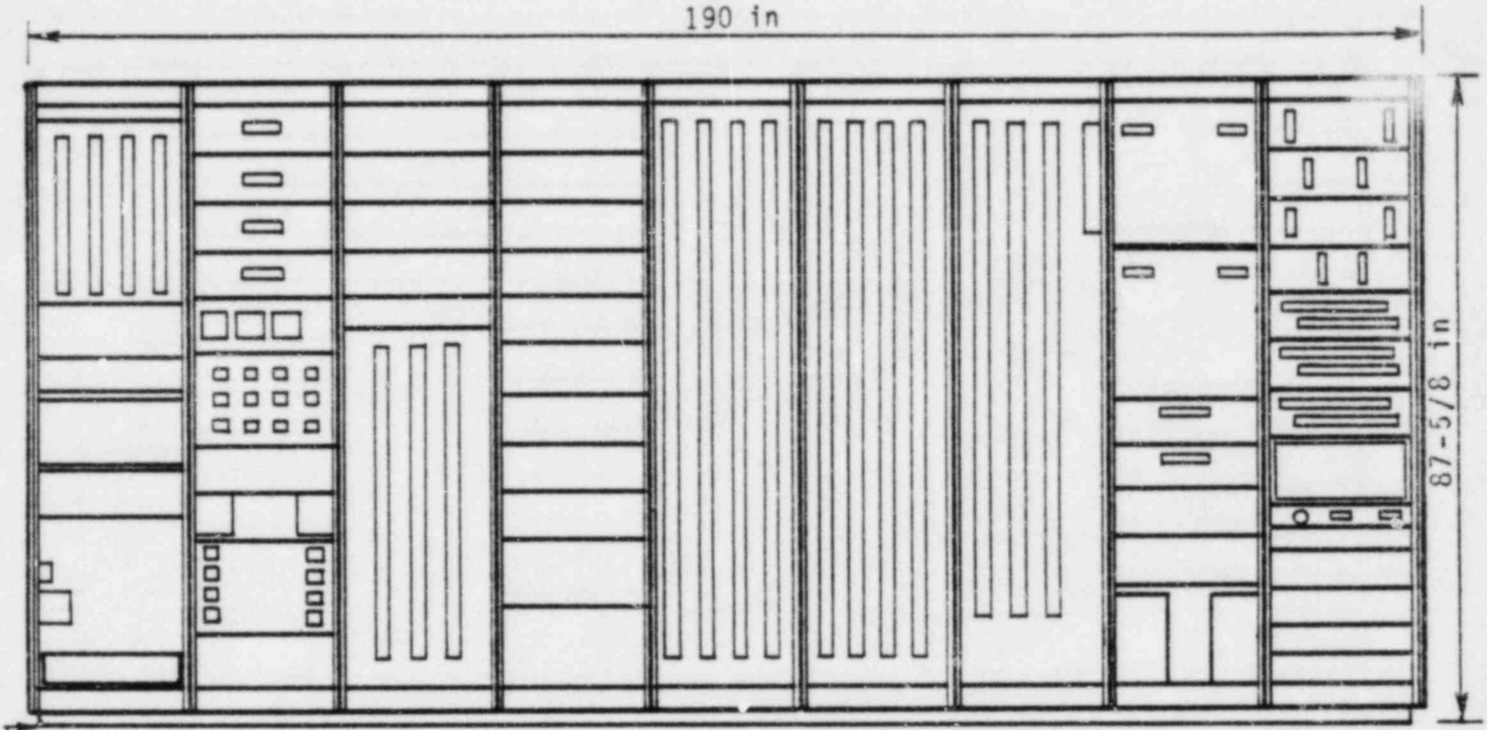


Figure 5

Main Annunciator Cabinet Assembly
Elevation View Looking West
(shown without doors)

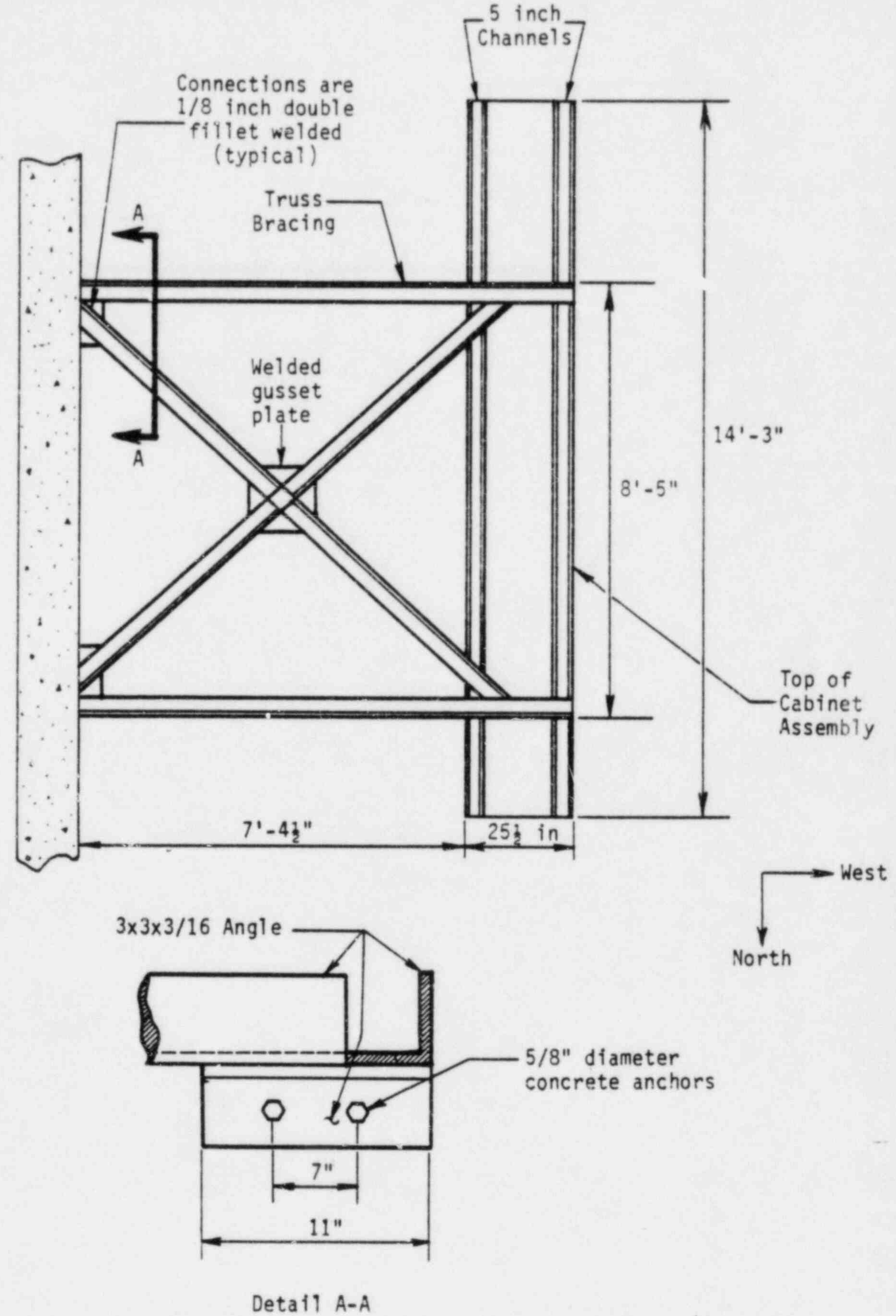


Figure 6

Truss Bracing
Plan View and Cross Section

3.2.1 Method of Verification Analysis

The IDVP developed a mathematical model of the main annunciator cabinet assembly after field verifying the configuration and selected dimensions of the cabinet and truss bracing (Reference 13). A single typical cabinet from the nine cabinet assembly was examined to determine its individual structural characteristics. The structure of this single cabinet was idealized as solely composed of the four internal 12 gauge formed steel members located at the corners of the cabinet. This simple model was deemed to be an adequate representation because the front and back doors do not close in plane with the cabinet structure and hence do not contribute to the shear capabilities in that plane.

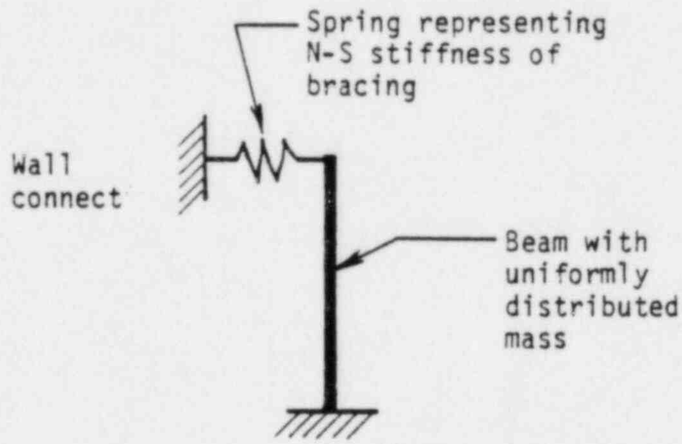
Figure 7 shows the verification analysis model for the main annunciator cabinet.

The stiffness of each of the four 12 gauge interior members was determined in the side-to-side direction. On the basis of these calculated stiffnesses, the stiffness of the complete cabinet assembly was then determined. The North-South (side-to-side) model was developed by first calculating the stiffness contribution of the truss bracing in the North-South direction. This stiffness was then included in the model with the cabinet stiffness.

The base of the cabinet assembly, which is welded to steel plates embedded in the floor, was assumed to be rigidly attached to the floor slab for all models.

The mass of each cabinet was assumed to be uniformly distributed along the height of the cabinet. This is a conservative assumption because the actual cabinets have the heavier components located towards the bottom.

The East-West (front-to-back) and vertical directions were not examined.



N-S Model

Figure 7

Verification Analysis Model
for Main Annunciator Cabinet

The natural frequency of the cabinet assembly in the North-South directions was calculated as 7.6 hertz.

Seismic accelerations were chosen from Hosgri response spectra at 4% damping to correspond to the IDVP natural frequencies. Since there are no response spectra available for elevation 127 feet, acceleration values were linearly interpolated between spectra values for elevations 115 feet and 140 feet. The interpolation also considered the height of the truss bracing attachment point. The spectra used in the verification analysis are listed in Appendix C.

An equivalent static method was used to determine the loads and forces from the 6.38g North-South seismic accelerations. These loads and forces were then used to calculate stresses at key areas (see Table 3). The calculated stresses were then compared to the allowables.

3.2.2 Results of Verification Analysis

The verification analysis computed loads and stresses at the following key areas and compared them to the allowables. The results show that the bracing concrete expansion anchor loads and the interior cabinet member loads for North-South loading exceed allowables (EOI 949).

Key Areas	Computed	Allowable
North-South Loading		
Truss bracing expansion anchor	2.04 *	1.0
Interior member bending	58.2 ksi	28.0 ksi

* Combined shear/tension interaction

Table 3

Comparison of Computed and Allowable Loads and Stresses in the Main Annunciator Cabinet Assembly

3.2.3 Design Analysis Methods

The design analysis of the main annunciator cabinet assembly modeled the dynamic characteristics using a lump mass and beam element computer model (Reference 14). The model, shown in Figure 8, only accounted for the front-to-back (East-West) motion of the cabinet assembly. The design analysis concluded that the cabinet assembly is rigid in the side-to-side direction because the doors were assumed to provide a substantial stiffness contribution in that direction when they were closed.

The model lumped the structural properties of the columns of adjacent cabinets together into a series of individual beam elements. A total of 30 lump masses are contained in the computer model. The mass of each cabinet was equally distributed to three lump masses located on each of the series of beams (see Figure 8 for the design analysis model representation). These lump masses are located at the center line of the horizontal reinforcing members. The model was set up such that degrees of freedom for the lump masses allowed for front-to-back motion only.

For boundary conditions, the design analysis assumed that the bottom of the cabinet assembly is fixed to the floor slab. At the top of the cabinet assembly, the model was laterally restrained at the brace attachment points.

Natural frequencies in the rigid range were calculated from this lump mass model. Seismic loadings for the assembly location at elevation 127 feet were obtained by interpolating between elevation 115 feet and 140 feet spectra. The seismic inputs used in the design analysis were compared to the Hosgri spectra. EOI 1008 was issued to note that the design analysis seismic inputs were taken from preliminary spectra. These seismic loadings were used to calculate stresses at four key locations. These stresses were then compared to the allowable stresses.

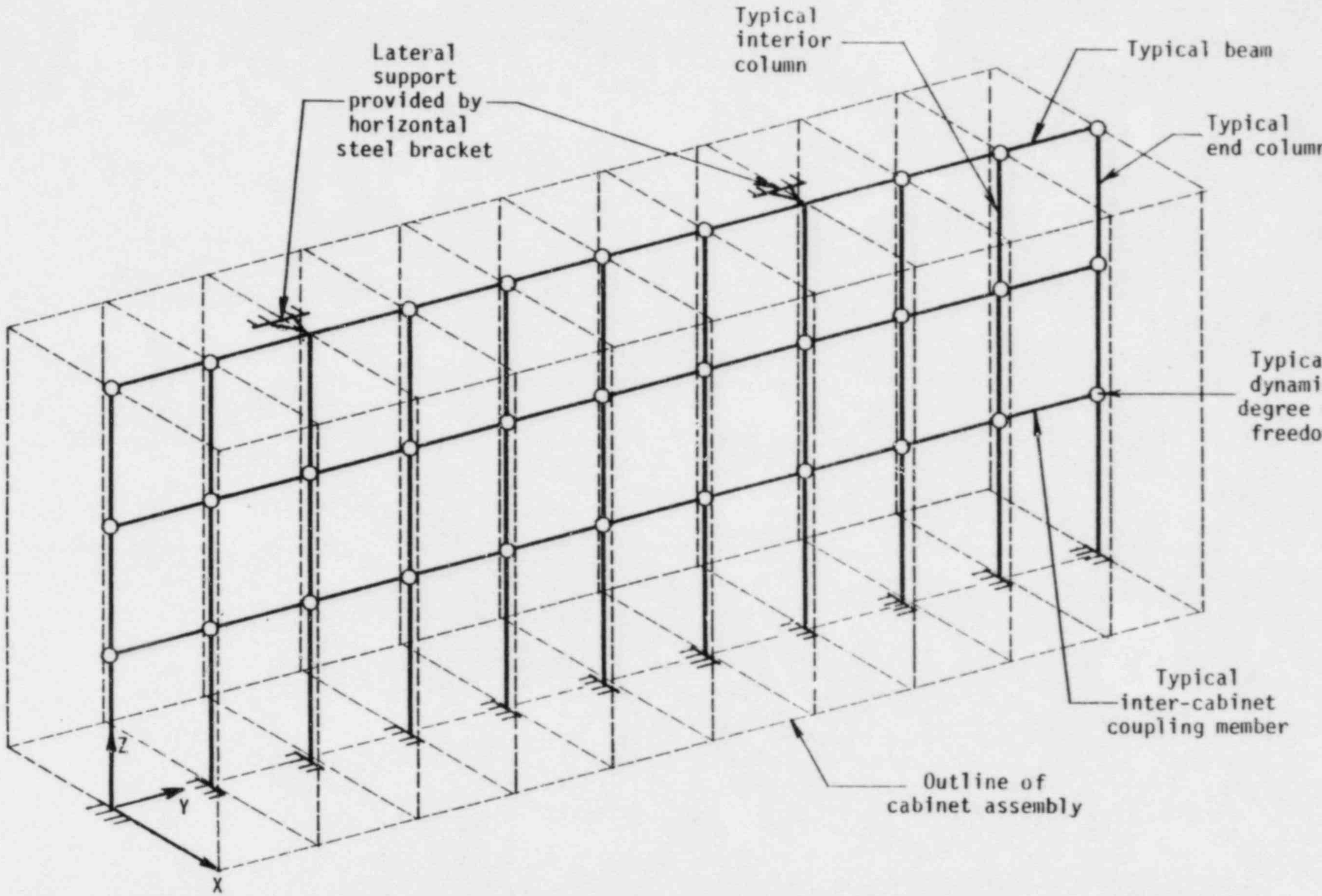


Figure 8

Design Analysis Computer Model

3.2.4 Comparison of Verification and Design Analysis Methods

The difference between the design analysis and the verification analysis is that the design analysis assumed that the cabinet assembly was rigid in the side-to-side (North-South) direction. Thus, the design analysis did not account for the effects of the amplified structural response in the side-to-side (North-South) direction.

The design analysis did not report loads and stresses in the upper truss bracing. The verification analysis of the connection between the truss bracing and the wall showed that when the structural response in the side-to-side (North-South) direction was accounted for, the expansion anchor bolt loads exceeded the allowable (EOI 949).

3.2.5 Error and Open Item Reports

The IDVP issued two EOI reports for the main annunciator cabinet assembly. Appendix A shows the EOI file number, revision, date and status.

EOI 949 was issued because the loads (determined by the IDVP) on the concrete expansion anchors securing the truss bracing to the wall exceeded the allowable. In addition, the design analysis assumed that the cabinet was rigid in the side-to-side direction. The concrete expansion anchor loads exceeded allowables because the design analysis did not examine the side-to-side motion based on this rigidity assumption. The IDVP found the side-to-side natural frequency of the structure to be in the flexible range.

PGandE is modifying the main annunciator cabinet assembly to make the cabinet assembly rigid in the side-to-side direction. EOI 949 is described as an Error Class A or B pending IDVP verification of the modification.

EOI 1008 was issued because the PGandE qualifying analysis for the main annunciator cabinet assembly referenced preliminary Hosgri response spectra (dated 4/4/77). Results of the verification analysis indicate that the use of preliminary spectra did not cause allowables to be exceeded. EOI 1008 was classified as a Class C Error.

4.0 EVALUATION OF ELECTRICAL EQUIPMENT ANALYSIS - INITIAL SAMPLE

4.1 INTERPRETATION

The IDVP performed analyses for two initial samples of electrical equipment qualified by analysis: the hot shutdown cabinet and the main annunciator cabinet assembly. The verification analysis found that the allowable criteria were met for the hot shutdown remote control cabinet but were exceeded in the main annunciator cabinet assembly.

Three EOIs were issued as a result of the comparison between the verification and design analyses methods and results (EOIs 949, 1087, and 1008). Two concerns were noted:

- The assumption in the design analysis that the main annunciator cabinet is rigid in the North-South direction was shown to be incorrect. This leads to a concern with rigidity assumptions (EOI 949).
- Spectra not contained in the Hosgri report were used in the analysis (EOI 1008).

4.2 RECOMMENDATIONS

The following recommendations address the concerns described in the interpretation section:

- Review the adequacy of all assumptions used in the frequency calculations for all electrical equipment qualified by analysis. These include instrument AC panel, instrument panels PIA, B and C, and local instrument panels. This additional verification is also described in ITR #1, Revision 1 (Reference 1).
- Review all seismic inputs as already set forth in the DCP Corrective Action Program.

5.0 ADDITIONAL VERIFICATION OF ELECTRICAL EQUIPMENT

5.1 SCOPE OF REVIEW

The IDVP reviewed the design analysis for the local instrument panels and instrument AC panels selected for additional verification. The recommendation for additional verification called for review of the design analyses for the assumptions used in the natural frequency calculations for all electrical equipment qualified by analysis (see Section 4.2, first recommendation).

The recommendation in Section 4.2 regarding seismic inputs is included in the DCP program of additional activities. This work will be verified by the IDVP and reported in a subsequent interim technical report describing control and application of Hosgri spectra.

5.2 RESULTS OF REVIEW

The IDVP reviewed the frequency calculations in the design analyses for the local instrument panels and the instrument AC panels. An error noted that unconservative static deflections were used in calculating the natural frequency. As a result, natural frequencies were overestimated. However, the natural frequency calculated by the IDVP using the correct formulation shows the panels to meet the frequency criteria, i.e., to be greater than 33 hertz.

5.3 EOI REPORTS ISSUED

The IDVP issued one EOI report for the additional verification of electrical equipment qualified by analysis. Appendix A shows the EOI file number, revision, data and status.

EOI 1117 was issued because the design analysis used an unconservative static deflection in the calculation of the instrument AC panel natural frequency. As a result, the natural frequency was overestimated. However, an IDVP calculation using the correct formulation determined that the panel had a natural frequency greater than 33 hertz and thus met the natural frequency criteria. Therefore, EOI 1117 was resolved as a Class C error.

6.0 CONCLUSION

The verification analysis for the initial sample of electrical equipment qualified by analysis found that the hot shutdown remote control cabinet meets the allowable criteria. However, a comparison of the design and verification analyses for the main annunciator cabinet indicates that the design analysis used an unrealistic assumption for the cabinet rigidity. Results of the verification analysis show that, as a result of postulated Hosgri seismic loading, allowable criteria have been exceeded for the main annunciator cabinet assembly (EOI 949). Additional verification of natural frequency assumptions was recommended.

The additional verification was performed to address the concern identified in the initial sample. One error has been noted arising from the additional verification (see Section 5.2). However, the IDVP found that the frequency criteria have been met for the local instrument panels and the instrument AC panels selected for additional verification.

7.0 REFERENCES

No.	Title	RLCA File No.
1	Interim Technical Report, Independent Design Verification Program, Additional Verification and Additional Sampling, Revision 1.	P105-4-839-001
2	DCNPP Independent Design Verification Program, Program Management Plan, Phase I, Revision 1, July 6, 1982.	P105-4-810-023
3	Interim Technical Report, Independent Design Verification Program, Shake Table Testing, Revision 0.	P105-4-839-004
4	RLCA Preliminary Report - Seismic Reverification Program, November 12, 1981.	
5	PGandE Final Safety Analysis Report, USAEC Docket Nos. 50-275 and 50-273.	P105-4-200-005
6	PGandE Report: "Seismic Evaluation for Postulated 7.5M Hosgri Earthquake," USNRC Docket Nos. 50-275 and 50-323.	P105-4-200-001
7	AISC, "Manual of Steel Construction," 7th Edition, 1973.	
8	PGandE Engineering Standard, Drawing No. 054162, Revision 3, "Concrete Expansion Anchors for Seismic and Static Loading."	P105-4-455-054
9	DCNPP Independent and Design Verification Program, Program Procedure, Phase I, Engineering Program Plan, Revision 0, March 31, 1982.	
10	RLCA Verification Analysis of the Hot Shutdown Remote Control Panel, Revision 2.	P105-4-570-004

No.	Title	RLCA File No.
11	PGandE Seismic Qualification of Hot Shutdown Panel, El. 100, Auxiliary Building, Diablo Canyon Nuclear Power Plant.	P105-4-437-004
12	IDVP Interim Technical Report, Pacific Gas & Electric - Westinghouse Seismic Interface Review, ITR #11, November 2, 1982.	
13	RLCA Verification Analysis - Main Annunciator Cabinet, Revision 3.	P105-4-570-001
14	Dynamic Seismic Analysis of Main Annunciator Cabinet Structure, Auxiliary Building, Diablo Canyon Power Plant, June, 1977.	P105-4-447-010
15	IDVP Interim Technical Report, Additional Verification and Additional Sampling, ITR #1, Revision 1.	
16	IDVP, Program Procedure, Preparation of Open Item Reports, Error Reports, Program Resolution Reports, and IDVP Completion Reports, DCNPP-IDVP-PP-003, Revision 1.	
17	RLCA Review, Electrical Panels - Additional Verification, Revision 0.	P105-4-506-012

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Appendix A

EOI Status - Electrical Equipment Analysis

(2 pages)

Appendix A

Error and Open Item Reports

EOI File No.	Subject	Rev.	Date	By	Type	Action Required	Physical Mod.
949	Main Annunciator Cabinet- Stresses Exceed Allowables	0 1 2	1/20/82 4/21/82 9/3/82	RLCA RLCA TES	OIR PER/AorB OIR	RLCA TES RLCA	 Yes
1004	Documentation of Formal Transmittals of spectra to Westinghouse (issued as a result of the RLCA Pre- liminary Report, 11/12/82)	0 1 2 3 4 5 6	2/6/82 3/22/82 4/17/82 5/24/82 6/9/82 6/22/82 6/22/82	RLCA RLCA TES TES RLCA TES TES	OIR PPRR/DEV PRR/OIP OIR PPRR/CI PRR/CI CR	RLCA TES PGandE RLCA TES TES None	 No
1006	Documentation for Elec- trical Equipment Analysis (issued as a result of the Preliminary Report, 11/12/82)	0 1 2	2/6/82 3/9/82 4/21/82	RLCA RLCA TES	OIR PPRR/CI CR	RLCA TES None	 No
1007	Documentation for Elec- trical Equipment Analysis (issued as a result of the Preliminary Report, 11/12/82)	0 1 2	2/6/82 3/9/82 4/21/82	RLCA RLCA TES	OIR PPRR/CI CR	RLCA TES None	 No
1008	Main Annunciator Cabinet- Preliminary Spectra	0 1 2 3	2/9/82 3/18/82 6/8/82 10/18/82	RLCA RLCA TES TES	OIR PER/C ER/C CR	RLCA TES PGandE None	 No

STATUS: Status is indicated by the type of classification of latest report received by PGandE:

- OIR - Open Item Report
- PPRR - Potential Program Resolution Report
- PRR - Program Resolution Report
- PER - Potential Error Report
- OIP - Open Item with future action by PGandE
- ER - Error Report
- CR - Completion Report
- CI - Closed Item
- DEV - Deviation
- A - Class A Error
- B - Class B Error
- C - Class C Error
- D - Class D Error

PHYSICAL MOD: Physical modification required to resolve the issue. Blank entry indicates that modification has not been determined.

Appendix A

Error and Open Item Reports

EOI File No.	Subject	Rev.	Date	By	Type	Action Required	Physical Mod.
1087	Hot Shutdown Remote Control Panel 15% Difference	0	5/14/82	RLCA	OIR	RLCA	
		1	5/26/82	RLCA	PPRR/CI	TES	
		2	5/28/82	RLCA	PPRR/CI	TES	
		3	6/23/82	TES	PRR/CI	TES	
		4	6/23/82	TES	CR	None	No
1117	Instr. Power AC Panels, unconservative stiffness calculated	0	3/16/83	RLCA	OIR	RLCA	
		1	3/16/83	RLCA	PER/C	TES	
		2	3/26/83	TES	ER/C	PGandE	
		3	4/19/83	TES	CR	None	No

STATUS: Status is indicated by the type of classification of latest report received by PGandE:

OIR - Open Item Report
PPRR - Potential Program Resolution Report
PRR - Program Resolution Report
PER - Potential Error Report
OIP - Open Item with future action by PGandE

ER - Error Report
CR - Completion Report
CI - Closed Item
DEV - Deviation

A - Class A Error
B - Class B Error
C - Class C Error
D - Class D Error

PHYSICAL MOD: Physical modification required to resolve the issue. Blank entry indicates that modification has not been determined.

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Appendix B

Key Term Definitions

(6 pages)

KEY TERMS AND DEFINITIONS USED IN
THE ELECTRICAL EQUIPMENT ANALYSIS REPORT

(The definitions in this glossary establish the meanings of words in the context of their use in this document. These meanings in no way replace the specific legal and licensing definitions.)

Acceptance Criteria

- The comparison between the design analysis and the independent analysis where the results must agree within 15% and be below allowable. Failure to meet this acceptance criteria results in the issuance of an Open Item.

Allowable Criteria

- Maximum stress or load provided by the licensing criteria.

Closed Item

- A form of program resolution of an Open Item which indicates that the reported aspect is neither an Error nor a Deviation. No further IDVP action is required (from Reference 16).

Completion Report

- Used to indicate that the IDVP effort related to the Open Item identified by the File Number is complete. It references either a Program Resolution Report which recategorized the item as a Closed Item or a PGandE document which states that no physical modification is to be applied in the case of a Deviation or a Class D Error (from Reference 16).

DCNPP-1

- Diablo Canyon Nuclear Power Plant Unit 1

Design Codes

- Accepted industry standards for design (ex. AISC, AISI, ANSI, ASME, AWWA, IEEE).

EOI

- Error and Open Item Report

Error Report

- An Error is a form of program resolution of an Open Item indicating an incorrect result that has been verified as such. It may be due to a mathematical mistake, use of wrong analytical method, omission of data or use of inapplicable data.

  Each Error shall be classified as one of the following:

- o Class A: An Error is considered Class A if design criteria or operating limits of safety related equipment are exceeded and, as a result, physical modifications or changes in operating procedures are required. Any PGandE corrective action is subject to verification by the IDVP.

- o Class B: An Error is considered Class B if design criteria or operating limits of safety related equipment are exceeded, but are resolvable by means of more realistic calculations or retesting. Any PGandE corrective action is subject to verification by the IDVP.

- o Class C: An Error is considered Class C if incorrect engineering or installation of safety related equipment is found, but no design criteria or operating limits are exceeded. No physical modifications are required, but if any are applied they are subject to verification by the IDVP.

- o Class D: An Error is considered Class D if safety related equipment is not affected. No physical modifications are required, but if any are applied, they are subject to verification by the IDVP (from Reference 16).

FSAR

- PGandE's Final Safety Analysis Report

Hosgri Criteria

- Licensing criteria referring specifically to the postulated 7.5M Hosgri earthquake.

Hosgri Report

- A report issued by PGandE that summarizes their evaluation of the DCNPP-1 for the postulated Hosgri 7.5M earthquake. Includes seismic licensing criteria.

Hosgri 7.5M Earthquake

- Maximum earthquake for which the plant is designed to remain functional. Same as Safe Shutdown Earthquake (SSE).

Interim Technical Report

- Interim technical reports are prepared when a program participant has completed an aspect of their assigned effort in order to provide the completed analysis and conclusions. These may be in support of an Error, Open Item or Program

Interim Technical Report (cont)

Resolution Report or in support of a portion of the work which verifies acceptability. Since such a report is a conclusion of the program, it is subject to the review of the Program Manager. The report will be transmitted simultaneously to PGandE and to the NRC (from Reference 2).

Licensing Criteria

- Contained in PGandE Licensing Documents, includes allowable criteria (See Hosgri Report definition).

NRC

- Nuclear Regulatory Commission.

NRC Order Suspending License CLI-81-30

- The order dated November 19, 1981 that suspended the license to load fuel and operate DCNPP-1 at power levels up to 5% of full power and specified the programs that must be completed prior to lifting of the suspension.

Open Item

- A concern that has not been verified, fully understood and its significance assessed. The forms of program resolution of an Open Item are recategorized as an Error, Deviation, or a Closed Item. (From Reference 16).

PGandE

- Pacific Gas and Electric Company.

Phase I Program

- Review performed by RLCA, RFR, and TES restricted to verifying work performed prior to June 1978 related to the Hosgri re-evaluation design activities of PGandE and their seismic service-related contractors.

Potential Program Resolution Report
and Potential Error Report

- Forms used for communication within IDVP.

Program Resolution Report

- Used to indicate that the specific item is no longer active in the IDVP. It indicates whether the resolution is a Closed Item, a Deviation, or that responsibility for an Open Item has been transferred to the PGandE Technical Program. Further IDVP action is required upon completion of the associated PGandE Technical Program Task if the IDVP transfers an Open Item to PGandE or if physical modifications are applied with respect to a deviation (Reference 16).

Response

- The motion resulting from an excitation of a device or system under specified conditions.

Response Spectra

- Graph showing relationship between acceleration and frequency. Used in seismic analysis.

RLCA

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Sample

- Initial Sample stipulated in Phase I Program of equipment, components, and buildings to be design verified by independent analysis.

Sampling Approach

- Method used by the IDVP to determine the initial sample (buildings, piping, equipment and components) for analysis and to provide for sample expansion when required.

SSE

- Safe Shutdown Earthquake: Maximum earthquake for which the plant is designed to remain functional (Hosgri 7.5M).

Seismic

- Refers to earthquake data.

Single Degree of Freedom Model

- Simplified mathematical representation of a structure.

TES

- Teledyne Engineering Services.

Verification Program

- Undertaken by the IDVP to evaluate Diablo Canyon Nuclear Power Plant for compliance with the licensing criteria.

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Appendix C

Hosgri Response Spectra Considered

in IDVP Electrical Equipment Analysis

(1 page)

APPENDIX C

HOSGRI RESPONSE SPECTRA CONSIDERED IN THE IDVP ELECTRICAL EQUIPMENT ANALYSIS

Hot Shutdown Remote Control Cabinet

Horizontal: Figures *	4-114, 4-119, 4-123, 4-127 4-132, 4-137, 4-141, 4-145
Vertical: Figures *	4-150

Main Annunciator Cabinet

Horizontal: Figures *	4-112, 4-113, 4-117, 4-118, 4-121, 4-122, 4-125, 4-126,

*Figure numbers correspond to those from the Hosgri Report (Reference 6).

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Appendix D

Program Manager's Assessment

(1 page)

APPENDIX D

PROGRAM MANAGERS ASSESSMENT

As IDVP Program Manager, TELEDYNE ENGINEERING SERVICES (TES) has established a Review and Evaluation Team, headed by a qualified team leader, as described in Section 7.4 (C) of the Phase I Program Management Plan (Rev. 1). The assigned team leader for the area, Electrical Equipment, included in the Interim Technical Report, has personally discussed the procedures, approach, field trip files, analyses, calculations, etc. with RLCA personnel. In addition, the TES Team Leader has reviewed the Open Item Files pertaining to this area of responsibility and, in particular, those fields for which RLCA has issued Potential Program Resolution Reports or Potential Error Reports, and on the basis of this evaluation, has recommended appropriate resolution to the IDVP Program Manager. Similar review procedures as described above for the initial sample were followed in the review of the RLCA additional verification.

Based on this review and evaluation process to date, the Team Leader, along with the TES Program Management Team, has studied and has concurred with the Interpretation and Recommendations outlined in Sections 4.1 and 4.2 of this report as well as the Conclusions stated in Section 6.0.