Robert L. Cloud and Associates, Inc.

RLCA

Interim Technical Report

DIABLO CANYON UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM
ELECTRICAL EQUIPMENT ANALYSIS
ITR #33
REVISION 0

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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

ELECTRICAL EQUIPMENT BY ANALYSIS

This is 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.

This report summarizes 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. All EOI files initiated for this sample category have been closed or identified as an error.

As IDVP Program Manager, Teledyne Engineering Services has approved this 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
Assistant Project Manager

ELECTRICAL EQUIPMENT ANALYSIS

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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.

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, an examination of trends and concerns, and a conclusion (Reference 1). 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 IE 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 2).

Summary

Robert L. Cloud and Associates (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. Methodologies 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, and exceeded for the main annunciator cabinet assembly as a result of an unrealistic design analysis assumption. A generic concern has been identified and recommendations for additional verification have been made.

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 3). 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 transmitted to the NRC staff in December 1981 and discussed on February 3, 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.

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 4 and 5).

Allowable criteria have been taken from the "Steel Construction Handbook, Seventh Edition" (Reference 6). Allowable criteria for concrete expansion anchors have been taken from PGandE Drawing 054162, Revision 3, "Concrete Expansion Anchors for Seismic and Static Loading", (Reference 7). Loading combinations are also included in Attachment I of the Phase I Engineering Program Plan (Reference 8).

3.0 VERIFICATION ANALYSIS OF ELECTRICAL EQUIPMENT

3.1 HOT_SHUTDOWN_REMOTE_CONTROL_CABINET

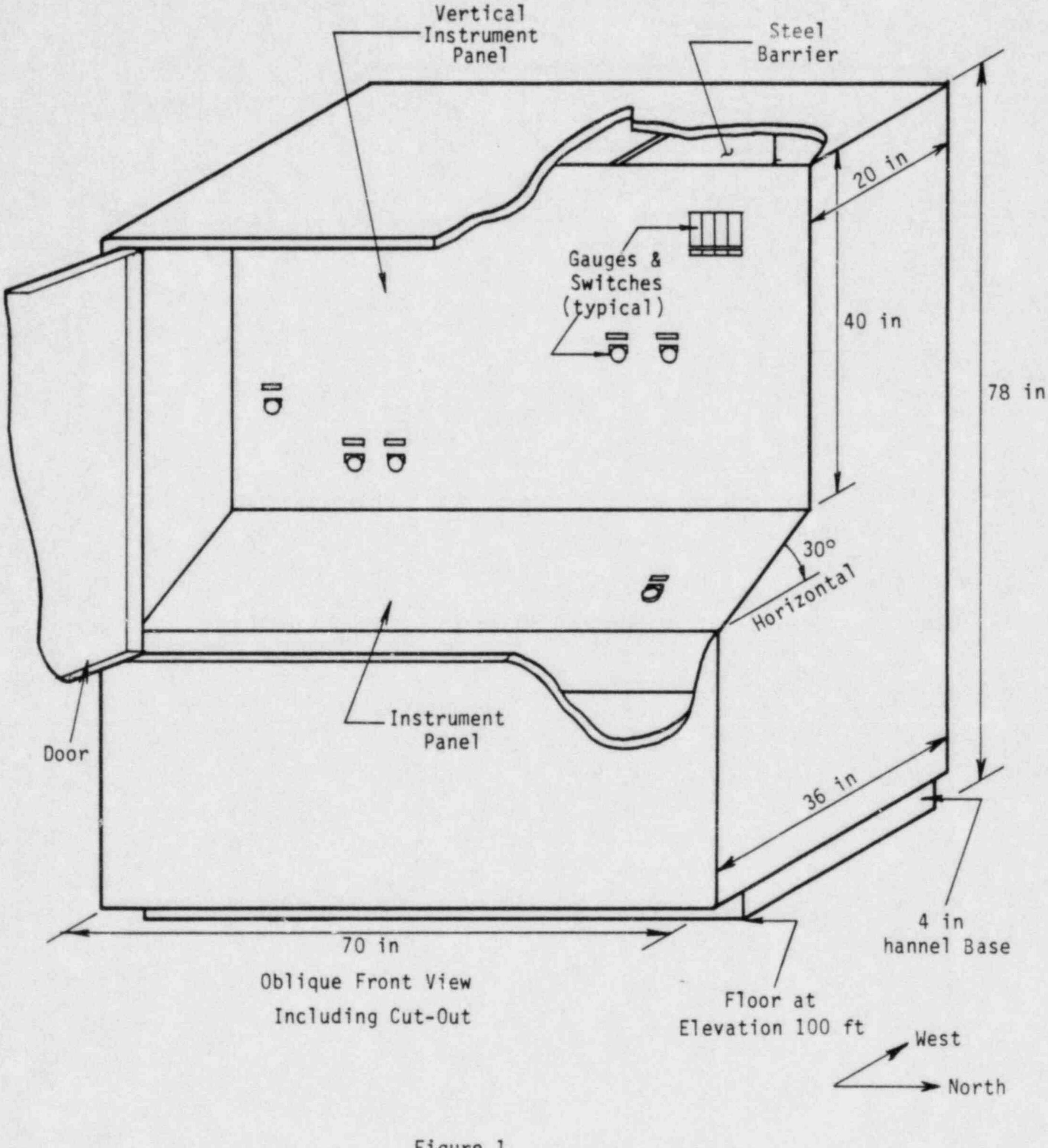
The hot shutdown remote control cabinet (called a panel in the Hosgri Report) is located at the West end of the Unit 1 auxiliary building at elevation 100 feet. The cabinet contains indicators and manual controls for various pumps and valves in the auxiliary feedwater, boration control, and containment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

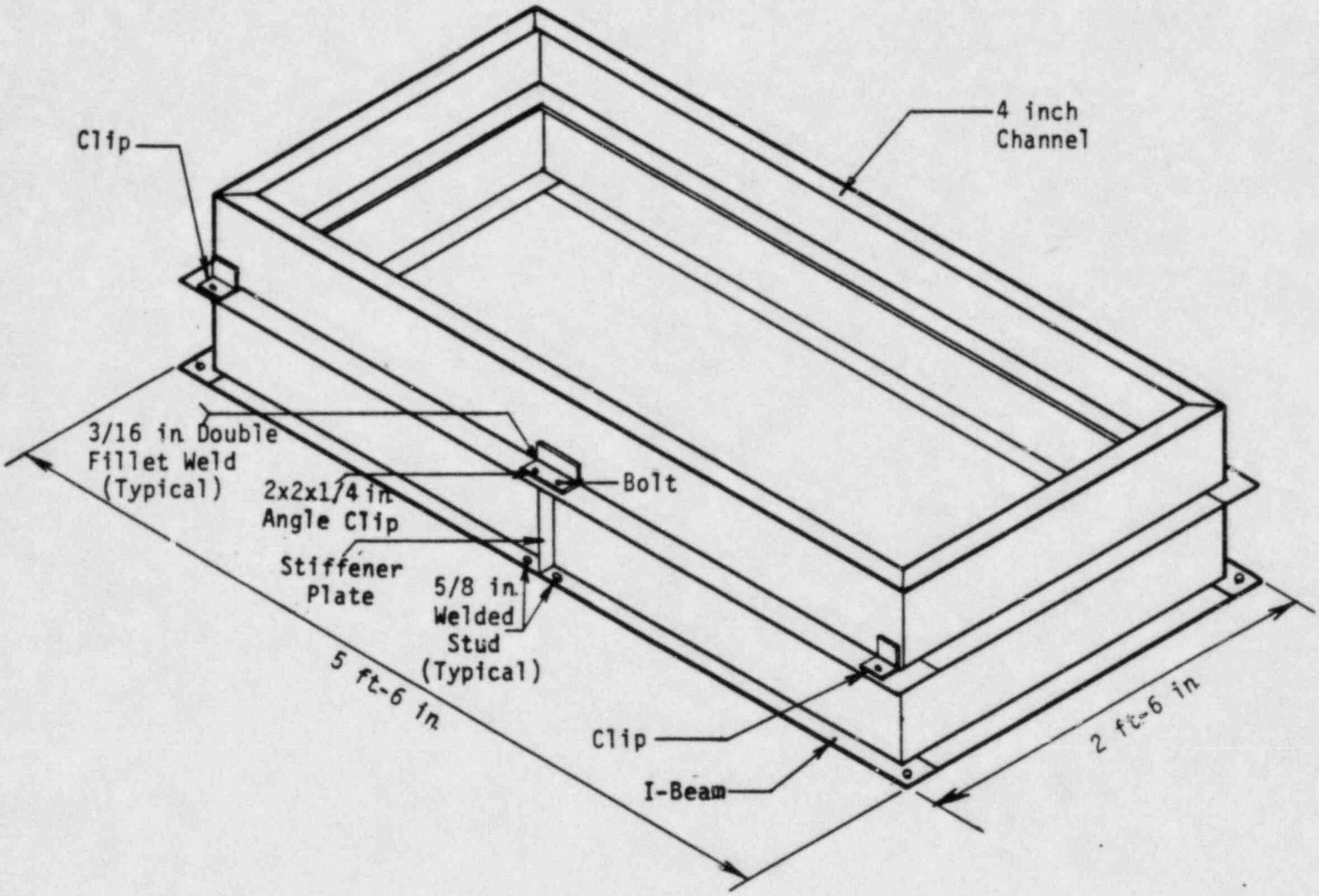


Figure 2

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 9).

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 5). 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.

Local Dynamic Characteristics

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.

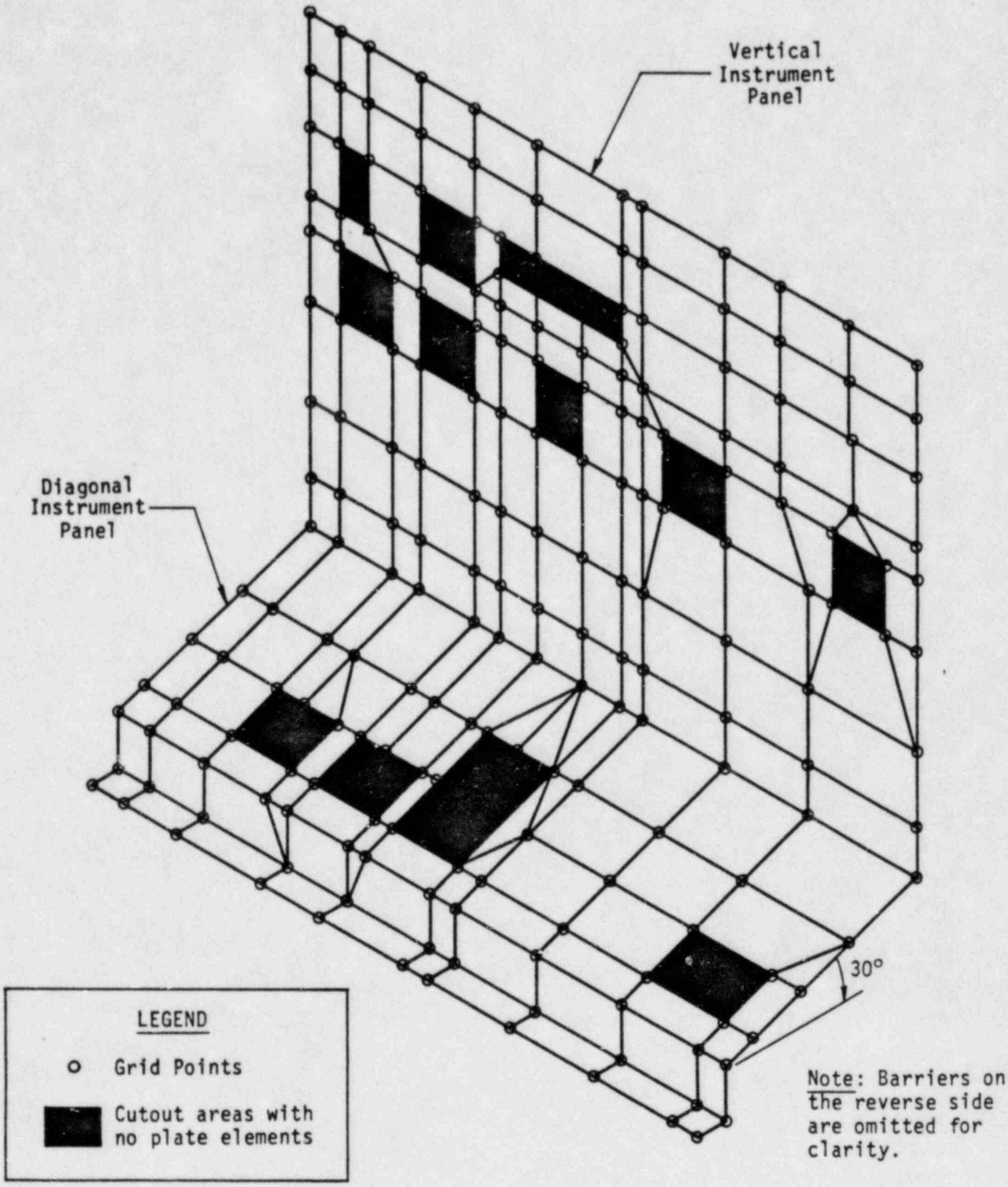


Figure 3

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 guage 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 10).

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.

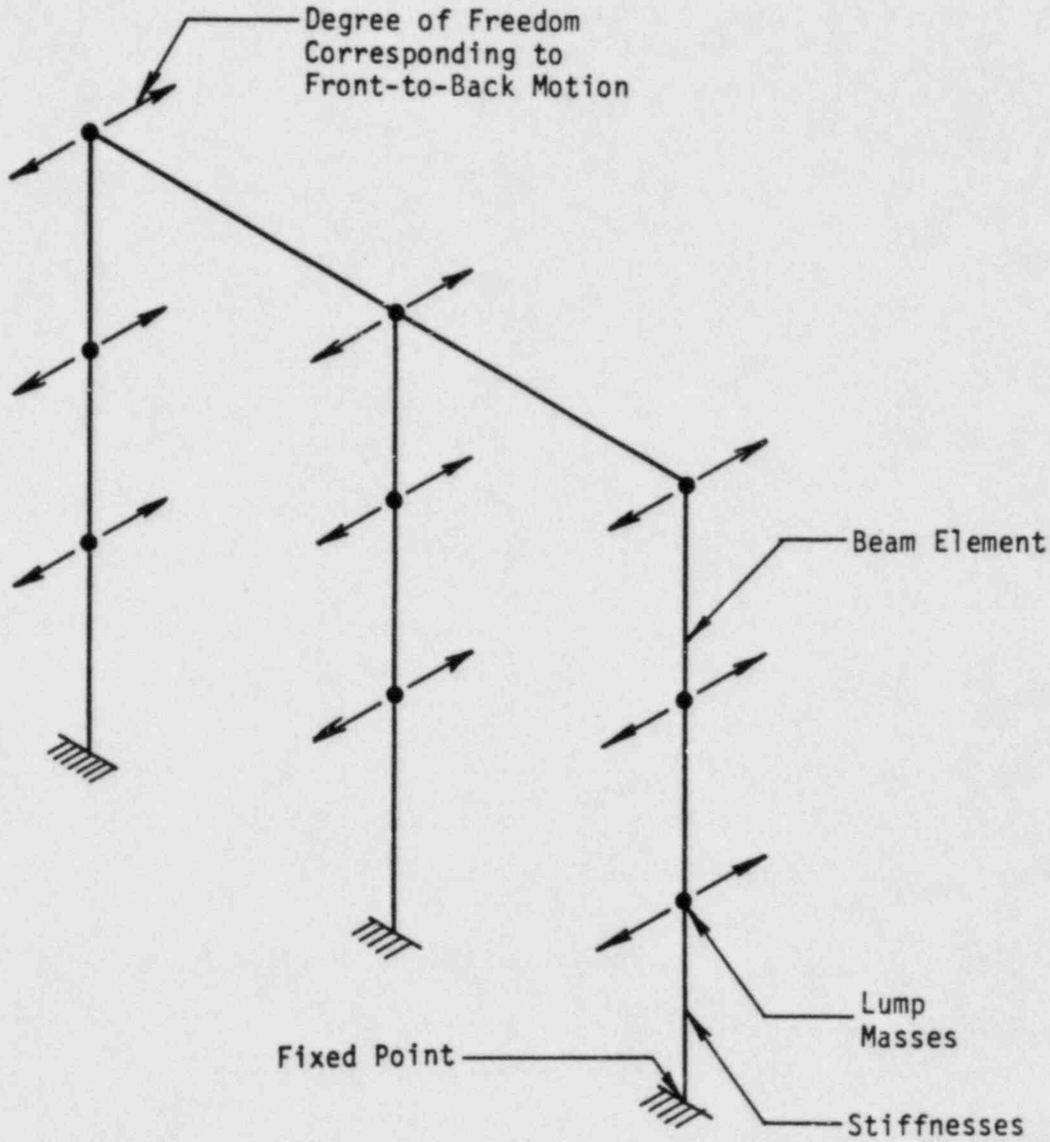


Figure 4

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 3).

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 11). 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.

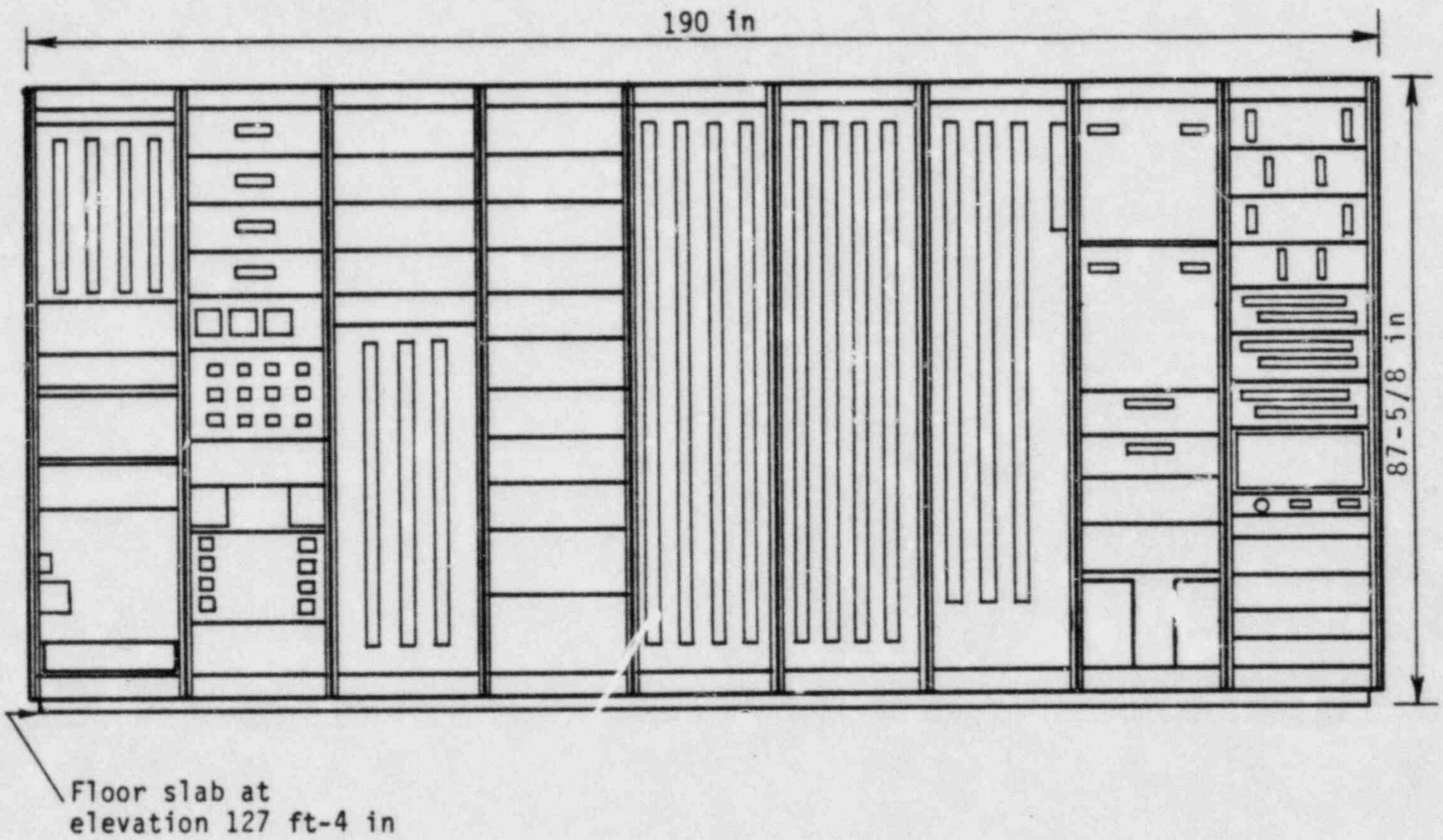


Figure 5

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

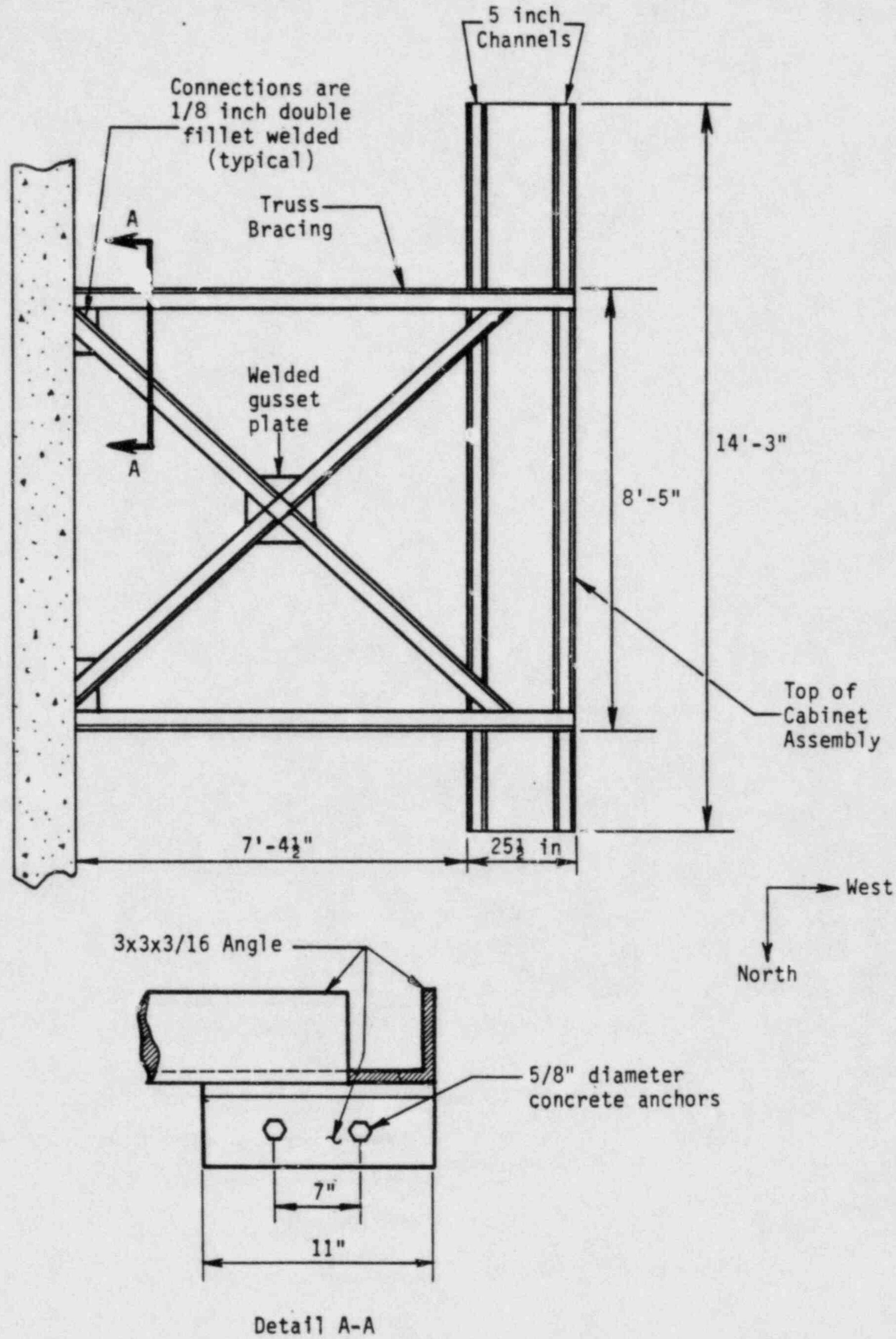


Figure 6

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 12). 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.

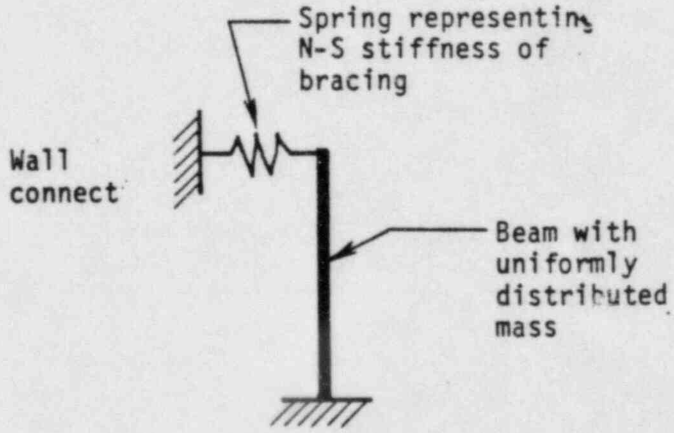
Figure 7 shows the verification analysis model for the main annunciator cabinet.

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 13). 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.

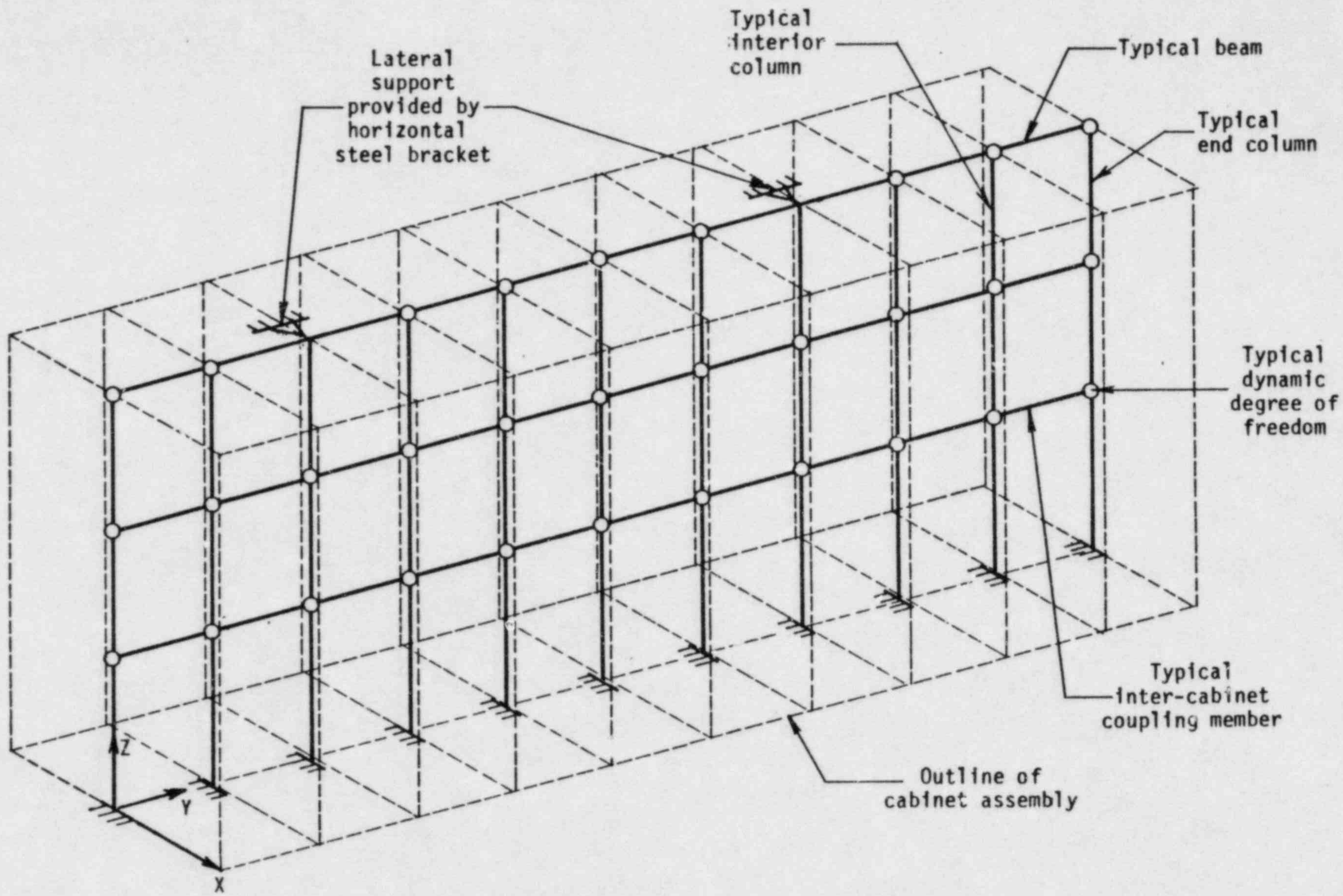


Figure 8

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

4.1 INTERPRETATION

The IDVP performed analyses for two 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 and exceeded in the main annunciator cabinet assembly.

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

- o 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).
- o 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:

- o 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 14).
- o Review all seismic inputs as already set forth in the DCP corrective action program.

5.0 CONCLUSION

The verification analysis found that the hot shutdown remote control cabinet meets the allowable criteria.

Review and comparison of the design analysis and the verification analysis indicates that the design analysis used an unrealistic assumption for the main annunciator cabinet rigidity. The 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 has been recommended to address this concern.

6.0 REFERENCES

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

No.	Title	RLCA File No.
10	PGandE Seismic Qualification of Hot Shutdown Panel, El. 100, Auxiliary Building, Diablo Canyon Nuclear Power Plant.	P105-4-437-004
11	IDVP Interim Technical Report, Pacific Gas & Electric - Westinghouse Seismic Interface Review, ITR #11, 11/2/82.	
12	RLCA Verification Analysis - Main Annunciator Cabinet, Revision 3.	P105-4-570-001
13	Dynamic Seismic Analysis of Main Annunciator Cabinet Structure, Auxiliary Building, Diablo Canyon Power Plant, June 1977.	P105-4-447-010
14	IDVP Interim Technical Report, Additional Verification and Additional Sampling, ITR #1, Revision 1.	
15	IDVP, Program Procedure, Preparation of Open Item Reports, Error Reports, Program Resolution Reports, and IDVP Completion Reports, DCNPP-IDVP-PP-003, Revision 1.	

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

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

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 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 15).

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 15).

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 15).

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 1).

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 15).

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 15).

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

- 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.

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.

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 5).

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 files 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.

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.

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