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HOPE CREEK GENERATING STATION
PLANT UNIQUE ANALYSIS REPORT
VOLUME 4
INTERNAL STRUCTURES ANALYSIS

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REVISION CONTROL SHEET

TITLE: Hope Creek Generating Station Plant Unique Analysis Report, Volume 4

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ABSTRACT

The primary containment for the Hope Creek Generating Station was designed, erected, pressure-tested, and N-stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section III, 1974 Edition with addenda up to and including Winter 1974. These activities were performed for the Public Service Electric and Gas Company (PSE&G) by the Pittsburgh-Des Moines Steel Company. Since then, new requirements which affect the design and operation of the primary containment system have been established. These requirements are defined in the Nuclear Regulatory Commission's (NRC) Safety Evaluation Report, NUREG-0661. The NUREG-0661 requirements define revised containment design loads postulated to occur during a loss-of-coolant accident or a safety-relief valve discharge event which are to be evaluated. In addition, NUREG-0661 requires that an assessment of the effects that these postulated events have on the operation of the containment system be performed.

This plant unique analysis report (PUAR) documents the efforts undertaken to address and resolve each of the applicable NUREG-0661 requirements for Hope Creek. It demonstrates, in accordance with NUREG-0661 acceptance criteria, that the design of the primary containment system is adequate and that original design safety margins have been restored. The Hope Creek PUAR is composed of the following six volumes:

- Volume 1 - GENERAL CRITERIA AND LOADS METHODOLOGY
- Volume 2 - SUPPRESSION CHAMBER ANALYSIS
- Volume 3 - VENT SYSTEM ANALYSIS
- Volume 4 - INTERNAL STRUCTURES ANALYSIS
- Volume 5 - SAFETY RELIEF VALVE DISCHARGE PIPING ANALYSIS
- Volume 6 - TORUS ATTACHED PIPING AND SUPPRESSION CHAMBER PENETRATION ANALYSES

Major portions of all volumes of this report have been prepared by NUTECH Engineers, Incorporated (NUTECH), acting as a consultant responsible to the Public Service Electric and Gas Company. Selected sections of Volumes 5 and 6 have been prepared by the Bechtel Power Corporation acting as an agent responsible to the Public Service Electric and Gas Company. This volume, Volume 4, documents the evaluation of the internal structures.

NOTE: Identification of the volume number precedes each page, section, subsection, table, and figure number.

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LIST OF ACRONYMS

ACI	American Concrete Institute
ADS	Automatic Depressurization System
AISC	American Institute of Steel Construction
ASME	American Society of Mechanical Engineers
ATWS	Anticipated Transients Without Scram
BDC	Bottom Dead Center
BWR	Boiling Water Reactor
CDF	Cumulative Distribution Function
CO	Condensation Oscillation
DBA	Design Basis Accident
DC	Downcomer
DLF	Dynamic Load Factor
ECCS	Emergency Core Cooling System
FSAR	Final Safety Analysis Report
FSI	Fluid-Structure Interaction
FSTF	Full-Scale Test Facility
HNWL	High Normal Water Level
HPCI	High Pressure Coolant Injection
IBA	Intermediate Break Accident
I&C	Instrumentation and Control
ID	Inside Diameter
IR	Inside Radius
LDR	Load Definition Report
LOCA	Loss-of-Coolant Accident

LIST OF ACRONYMS
(Continued)

LPCI	Low Pressure Coolant Injection
LTP	Long-Term Program
MC	Midcylinder
MCF	Modal Correction Factor
MJ	Mitered Joint
MVA	Multiple Valve Actuation
NEP	Non-Exceedance Probability
NOC	Normal Operating Conditions
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NVB	Non-Vent Line Bay
OBE	Operating Basis Earthquake
OD	Outside Diameter
PSD	Power Spectral Density
PSE&G	Public Service Electric and Gas Company
PUA	Plant Unique Analysis
PUAAG	Plant Unique Analysis Application Guide
PUAR	Plant Unique Analysis Report
PULD	Plant Unique Load Definition
QSTF	Quarter-Scale Test Facility
RCIC	Reactor Core Isolation Cooling
RHR	Residual Heat Removal
RPV	Reactor Pressure Vessel
RSEL	Resultant Static-Equivalent Load

LIST OF ACRONYMS

(Concluded)

SBA	Small Break Accident
SBP	Small Bore Piping
SER	Safety Evaluation Report
SORV	Stuck-Open Safety Relief Valve
SRSS	Square Root of the Sum of the Squares
SRV	Safety Relief Valve
SRVDL	Safety Relief Valve Discharge Line
SSE	Safe Shutdown Earthquake
STP	Short-Term Program
SVA	Single Valve Actuation
TAP	Torus Attached Piping
VB	Vent Line Bay
VH	Vent Header
VL	Vent Line
VPP	Vent Pipe Penetration
ZPA	Zero Period Acceleration

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4-1.0 INTRODUCTION

In conjunction with Volume 1 of the Plant Unique Analysis Report (PUAR), this volume documents the efforts undertaken to address the requirements defined in NUREG-0661 which affect the Hope Creek internal structures. The internal structures PUAR is organized as follows:

- INTRODUCTION
  - Scope of Analysis
- INTERNAL STRUCTURES ANALYSIS
  - Component Description
  - Loads and Load Combinations
  - Analysis Acceptance Criteria
  - Method of Analysis
  - Analysis Results and Conclusions

The INTRODUCTION section contains a general overview discussion of the internal structures evaluation. The INTERNAL STRUCTURES ANALYSIS section discusses the specific components, loads, criteria, methods, and results associated with the evaluation. A summary of the conclusions derived from the internal structures evaluation is also included.

4-1.1 Scope of Analysis

The general criteria presented in Volume 1 are used as the basis for the Hope Creek internal structures evaluations described in this volume. The internal structures evaluated include the catwalk and monorail. These structures are not required for the safe operation of the primary containment system during accident conditions.

The internal structures are evaluated for the effects of LOCA related loads, as defined by the NRC's Safety Evaluation Report NUREG-0661 (Reference 1) and the Mark I Containment Program Load Definition Report (LDR) (Reference 2).

The LOCA loads used in this evaluation are formulated using the procedures discussed in Volume 1 of this report. The evaluation includes structural analyses of the internal structures to ensure that these structures do not fail and result in damage to safety related components.

The results of the structural evaluation for each load are used to evaluate load combinations for the internal structures, in accordance with the Mark I Containment

Program Plant Unique Analysis Application Guide (PUAAG) (Reference 3). The evaluation results are conservatively compared with the acceptance limits specified by the applicable sections of the American Society of Mechanical Engineers (ASME) Code (Reference 4) to ensure that failure will not occur.

4-2.0 INTERNAL STRUCTURES ANALYSIS

An evaluation of each of the NUREG-0661 requirements which affect the design adequacy of the Hope Creek internal structures is presented in the sections which follow. The criteria used in the evaluation are contained in Volume 1 of this report.

The component parts of the internal structures which are examined are described in Section 4-2.1. The loads and load combinations which are evaluated are described and presented in Section 4-2.2. The analysis methodology used to evaluate the effects of these loads and load combinations is discussed in Section 4-2.4. The acceptance limits to which the analysis results are compared are discussed and presented in Section 4-2.3. The analysis results and the corresponding design margins are presented in Section 4-2.5.

4-2.1 Component Description

The internal structures which are evaluated include the catwalk and the monorail, which are described in Sections 4-2.1.1 and 4-2.1.2, respectively.

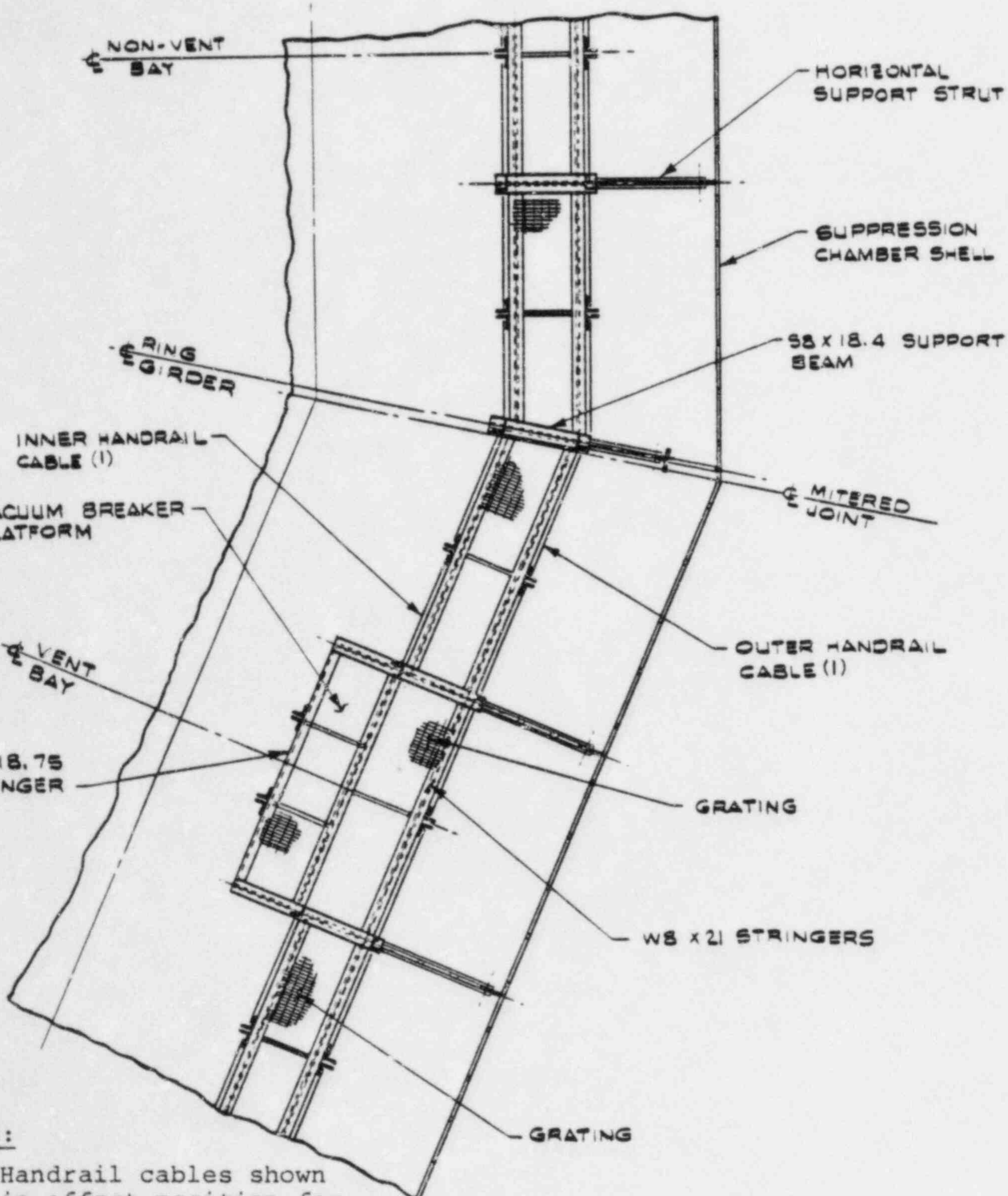
4-2.1.1 Catwalk

The catwalk is a platform-type structure approximately 3 feet wide, which extends around the full circumference of the suppression chamber. The catwalk is located in the upper outside quadrant of each suppression chamber mitered cylinder.

The catwalk frame consists of two W8 x 21 stringers which span between S8 x 18.4 support beams which are located at the mitered joint and at two intermediate locations between mitered joints. The mitered joint and intermediate supports consist of two vertical hangers and one horizontal support strut. The catwalk and catwalk support configurations are shown in Figures 4-2.1-1 and 4-2.1-2.

A vacuum breaker platform approximately 3' wide by 9' long is located adjacent to the catwalk at midcylinder of each vent line bay. The vacuum breaker platform is supported by two S8 x 18.4 platform support members. The vacuum breaker platform and support configurations are shown in Figures 4-2.1-1 and 4-2.1-3.

The catwalk and vacuum breaker platform are comprised of grating which is bolted to the catwalk frame. The catwalk frame is braced against lateral loads by the horizontal support struts.

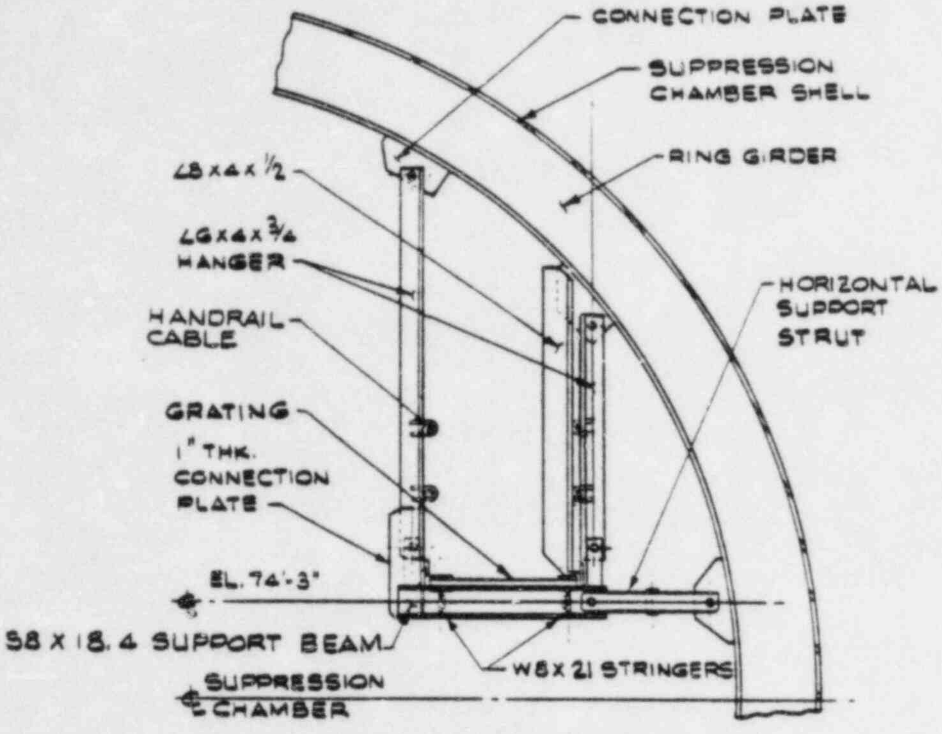


Note:

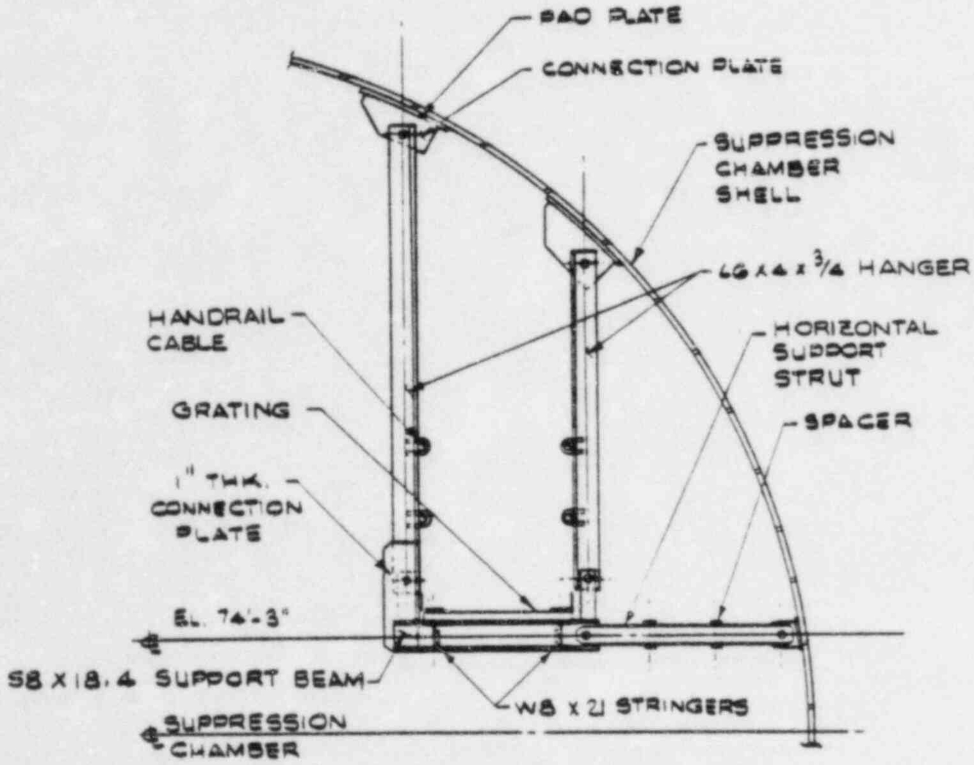
1. Handrail cables shown in offset position for clarity.

Figure 4-2.1-1

PLAN VIEW OF CATWALK SEGMENT



MITERED JOINT SUPPORTS



INTERMEDIATE SUPPORTS

Figure 4-2.1-2

CATWALK SUPPORT DETAILS

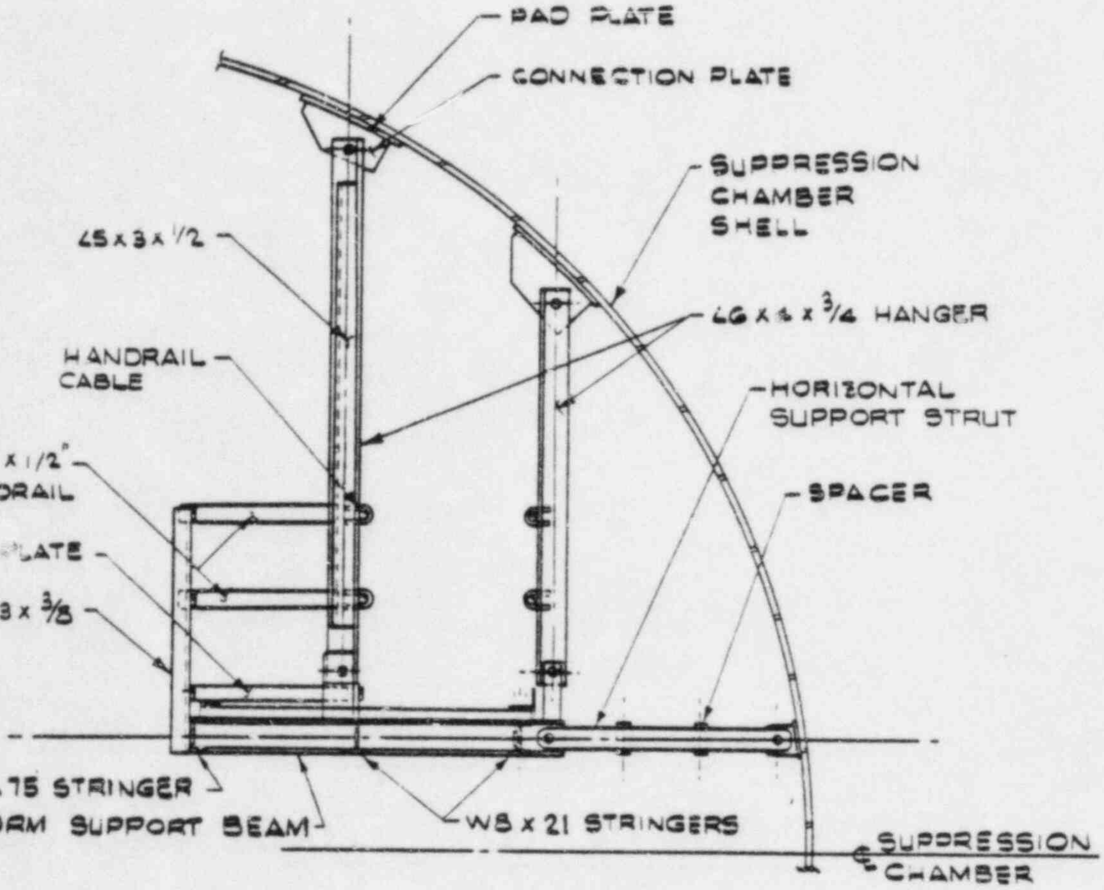


Figure 4-2.1-3

CATWALK SUPPORT DETAILS AT VACUUM BREAKER PLATFORM

4-2.1.2 Monorail

The monorail consists of S10 x 25.4 beam sections curved to a 60'-7" radius and connected end-to-end to form a continuous monorail beam around the circumference of the suppression chamber. The monorail is located in the upper outside quadrant of each suppression chamber mitered cylinder. The monorail configuration is shown in Figure 4-2.1-4.

The monorail beam is supported at each mitered joint and at one intermediate location between mitered joints. The intermediate supports are located at or near midcylinder.

The monorail supports consist of a vertical support member and a horizontal support member. The horizontal support members are constructed from a 2-1/8" x 1-1/2" bar sandwiched by two 2-1/2" x 2-1/2" x 5/16" thick angles. The bottom legs of the support angles are removed from the intermediate horizontal support members. The vertical support members are constructed from a combined section of a 2" x 1/2" solid bar and a 1-1/2" x 1-1/2" solid bar. Details of the monorail supports are shown in Figure 4-2.1-5.

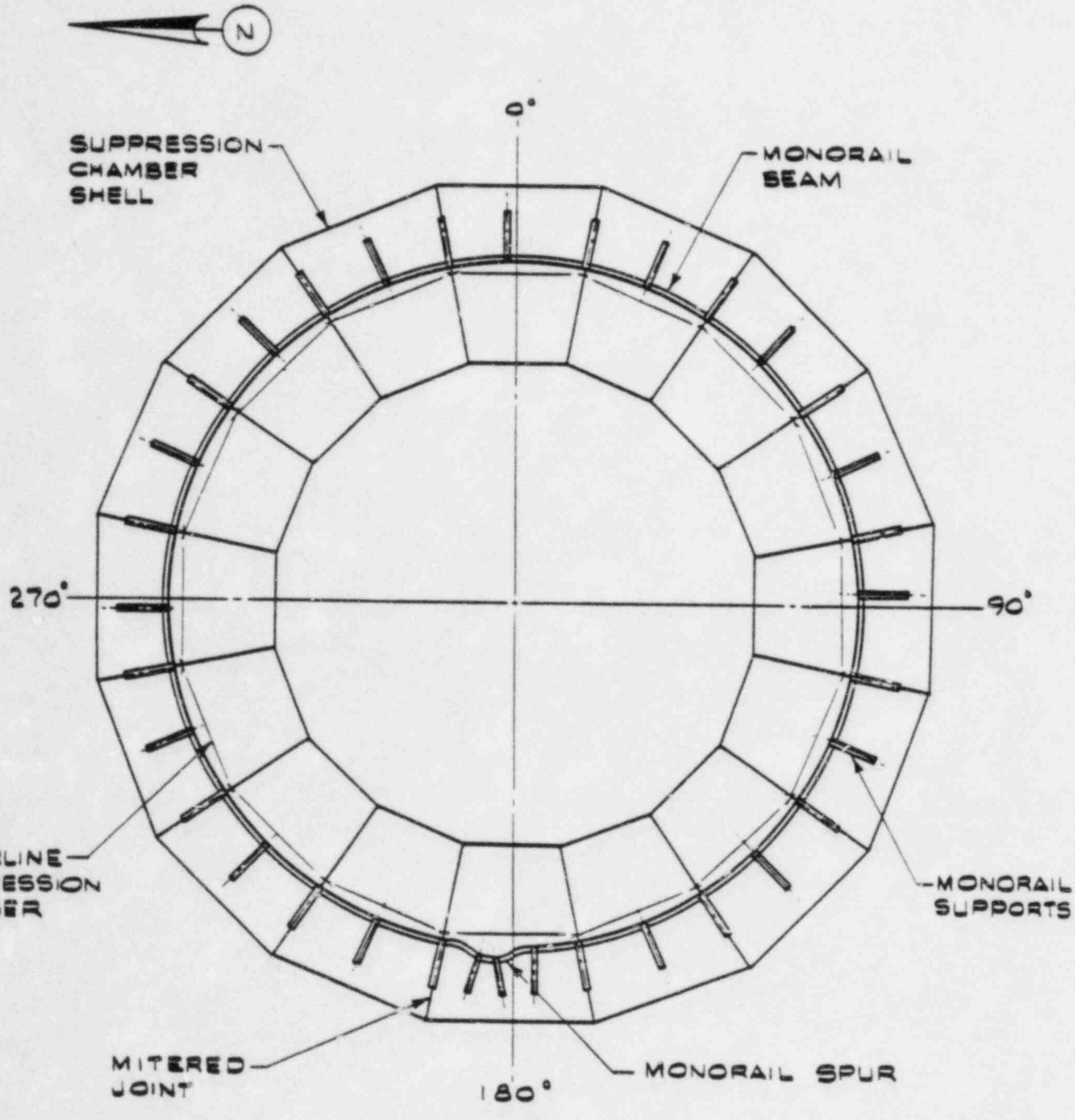
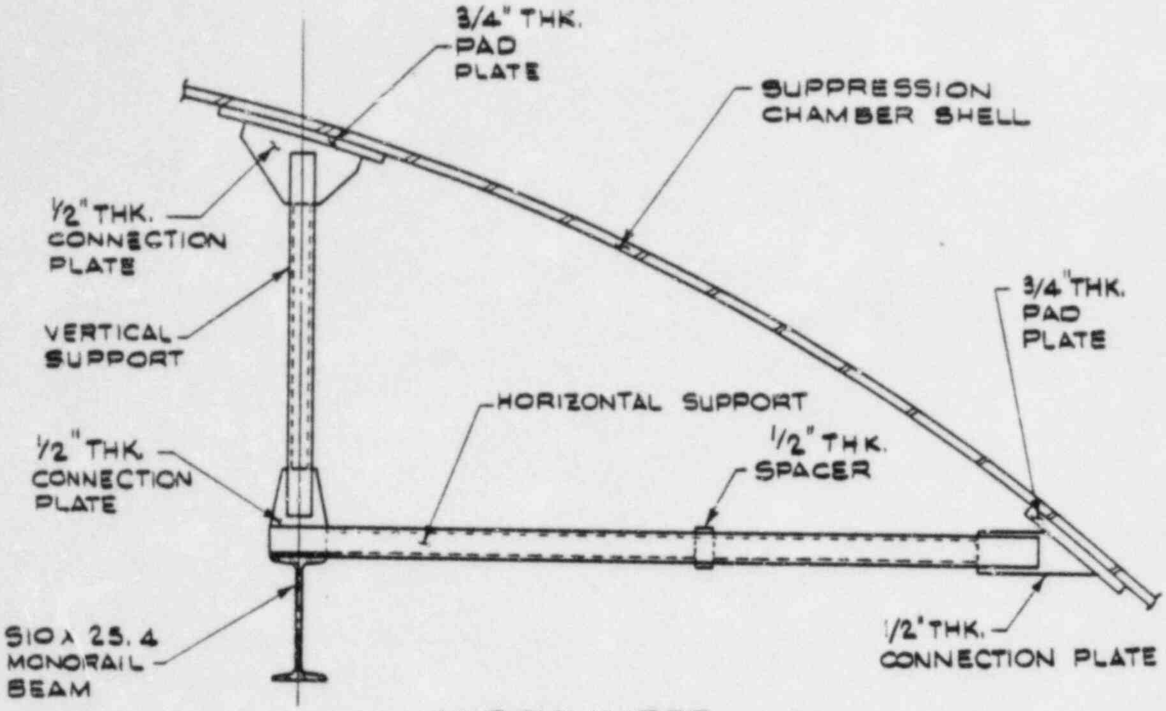
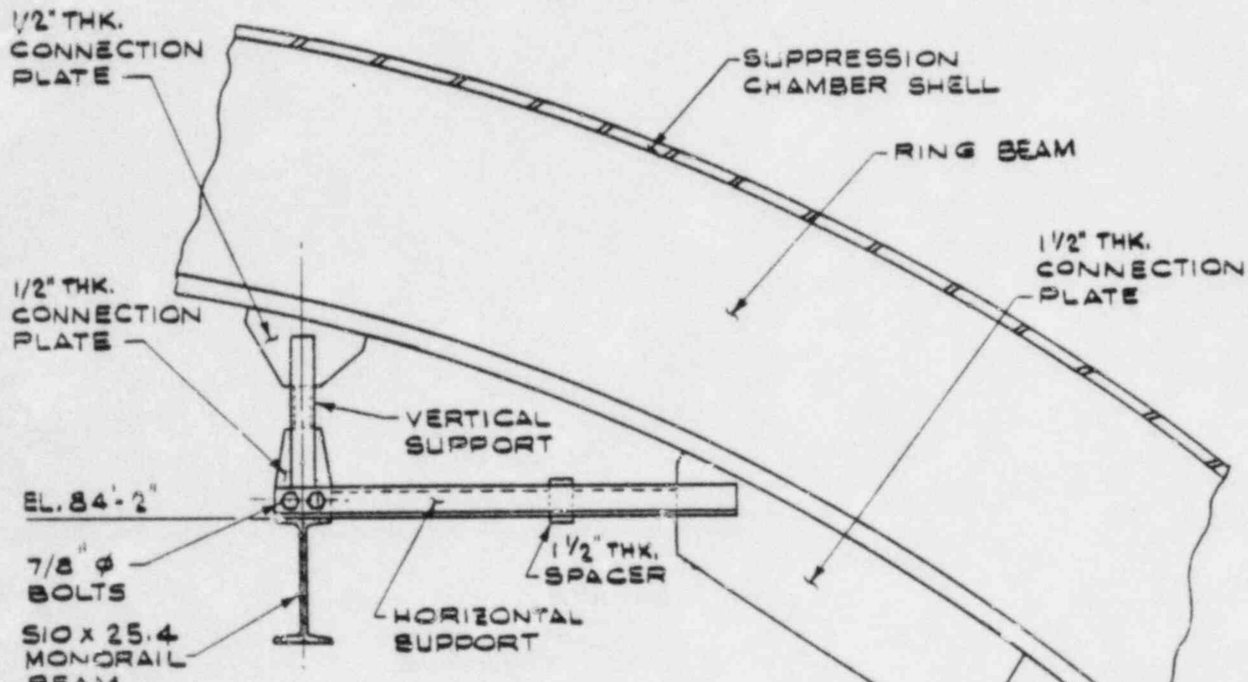


Figure 4-2.1-4

PLAN VIEW OF SUPPRESSION CHAMBER MONORAIL



MIDCYLINDER



MITERED JOINT

Figure 4-2.1-5

MONORAIL SUPPORT DETAILS

4-2.2 Loads and Load Combinations

The loads for which the Hope Creek internal structures are evaluated are defined in NUREG-0661 on a generic basis for all Mark I plants. The methodology used to develop plant unique loads, for each applicable load defined in NUREG-0661, is discussed in Section 1-4.0. The results of applying the methodology to develop specific values for each of the controlling loads are discussed and presented in Section 4-2.2.1.

The controlling load combinations which affect the internal structures are formulated by using the event combinations and event sequencing defined in NUREG-0661 and discussed in Sections 1-3.2 and 1-4.3. The controlling load combinations are discussed and presented in Section 4-2.2.2.

4-2.2.1 Loads

The loads acting on the internal structures are categorized as follows:

1. Dead Weight Loads

   1a. Dead Weight of Steel

2. Seismic Loads

   2a. OBE Loads

   2b. SSE Loads

3. Pool Swell Loads

   3a. Pool Swell Impact and Drag Loads

   3b. Froth Impingement and Fallback Loads

   3c. Pool Fallback Loads

4. Containment Interaction Loads

   4a. Containment Structure Motions

Table 4-2.2-1 shows the specific internal structures which are affected by each of the above loads. The methodology used to develop values for each of these loadings is discussed in Section 1-4.0. The resulting magnitudes and characteristics of each loading are similar to those described in Volume 3 of this report.

Table 4-2.2-1

INTERNAL STRUCTURES

COMPONENT LOADING IDENTIFICATION

Volume 4 Load Designation		PUAR Volume Section Reference	Catwalk	Monorail
Category	Case Number			
Dead Weight	1a	1-3.1	X	X
Seismic	2a	1-3.1	X	X
	2b	1-3.1	X	X
Pool Swell Loads	3a	1-4.1.4.2	X	
	3b	1-4.1.4.3	X	X
	3c	1-4.1.4.4	X	
Containment Interaction	7a	2-2.2	X	X

4-2.3.2 Load Combinations

The loadings which affect each of the internal structures are presented in Section 4-2.2.1. The general NUREG-0661 criteria for grouping these loads into event combinations are discussed in Section 1-3.2. Since the internal structures are located above the suppression pool, the event combinations which produce controlling stresses are those which contain pool swell loads. These include the DBA 18 and DBA 25 combinations as shown in Table 4-2.2-2. The catwalk and monorail are therefore evaluated for the DBA 18 and DBA 25 event combinations.

Table 4-2.2-2

CONTROLLING INTERNAL STRUCTURES

LOAD COMBINATIONS

Section 4-2.2.1 Load Designation	Event	DBA	
	NUREG-0661 Combination Number	18	25
1) Dead Weight		1a	1a
2) Seismic	OBE	2a	
	SSE		2b
3) Pool Swell Loads		3a-3c	3a-3c
7) Containment Interaction		7a	7a
Service Level	Torus Shell	B (1)	C
	Internal Structures	E	E

Note:

1. Evaluation of secondary stress range and fatigue not required.

4-2.3 Analysis Acceptance Criteria

The service level assignments for the internal structures and the suppression chamber shell at attachment points to internal structures are shown in Table 4-2.2-2. The table shows that all internal structures are designated as Service Level E components, and as such, are not required to meet ASME Code acceptance limits. In order to employ a consistent set of design criteria which ensures that failure will not occur, the internal structures are conservatively evaluated for the Service Level D acceptance limits contained in the ASME Code. The suppression chamber shell near attachment points to internal structures is evaluated in accordance with the requirements for Class MC components contained in the ASME Code. The corresponding allowable stresses for the internal structures are presented in Section 4-2.5 for the DBA 18 and DBA 25 combinations.

4-2.4 Method of Analysis

The loadings for which the internal structures are evaluated are identified in Section 4-2.2.1.

The analysis of the catwalk is performed using manual calculations to evaluate the stringers, hangers, and associated catwalk components. Equivalent static analyses are performed for pool swell impact loads, froth impingement loads, seismic loads, and containment interaction loads. The reaction loads in the catwalk hangers are used to evaluate local stresses in the suppression chamber shell.

The analysis of the monorail is performed using a beam model which includes the monorail beam and the monorail supports. Equivalent static analyses are performed for all monorail loadings. The reaction loads in the monorail supports are used to evaluate local stresses in the suppression chamber shell.

4-2.5 Analysis Results

The geometry, loads, load combinations, acceptance criteria, and analysis methods used in the evaluation of the internal structures are presented in the preceding sections. The resulting maximum stresses for the catwalk and monorail are shown in Table 4-2.5-1. The maximum suppression chamber shell and pad plate to shell weld stresses due to catwalk and monorail reaction loads are also reported in Table 4-2.5-1. As is evident from this table, the calculated stresses for these components are less than the corresponding allowable stresses.

Table 4-2.5-1

INTERNAL STRUCTURES STRESSES FOR CONTROLLING LOAD COMBINATIONS

Item	Material	Material Properties (ksi)	Stress Type	Load Combination Stresses (ksi)		
				DBA 25		
				Calc. Stress	Allowable Stress (Service Level E)	Calc. / Allow.
Catwalk Stringer	SA-36	S_y = 33.86, S_u = 58.0	Compressive	1.01	21.58	0.94 (1)
			Weak Axis Bending	12.58	50.80	
			Strong Axis Bending	29.00	44.69	
Catwalk Vertical Hanger Support	SA-36	S_y = 33.86, S_u = 58.0	Compressive	5.10	21.70	0.88 (1)
			Bending	23.20	40.63	
Catwalk Platform Support Beam	SA-36	S_y = 33.86, S_u = 58.0	Compressive	0.62	6.27	0.56 (1)
			Bending	18.88	40.63	
Monorail Beam	SA-36	S_y = 33.86, S_u = 58.0	Tensile	1.21	40.63	1.00 (1)
			Weak Axis Bending	40.59	50.79	
			Strong Axis Bending	5.24	30.96	
Monorail Vertical Support	SA-36	S_y = 33.86, S_u = 58.0	Compressive	4.85	22.57	0.65 (1)
			Bending	16.96	40.63	
Monorail Horizontal Support	SA-36	S_y = 33.86, S_u = 58.0	Compressive	2.96	8.61	0.78 (1)
			Bending	24.03	40.64	
Suppression Chamber Shell	SA-516 Gr. 70	S_{mc} = 19.3	Local Primary Membrane	20.73 (3)	28.95 (2)	0.72
Pad Plate to Shell Weld	SA-516 Gr. 70	S_{mc} = 19.3	Primary	2.54	15.01 (2)	0.17

Notes:

1. Values shown obtained from beam interaction equation.
2. Service Level B allowable conservatively used.
3. Stress shown includes combined effects of internal structure reaction loads and general shell stresses obtained from the suppression chamber analysis documented in Volume 2.

4-2.5.1 Conclusions

The values of the loads used to evaluate the internal structures are conservative estimates of the loads postulated to occur during an actual LOCA event. The event combinations for which the internal structures are evaluated envelop the actual events expected to occur during a LOCA event.

The acceptance limits to which the evaluation results are compared are more restrictive than those required by NUREG-0661. Use of these acceptance limits ensures that the internal structure components will not fail and cause damage to safety-related components.

As is evident from the analysis results presented, stresses in the internal structure components are within these conservative acceptance limits. The intent of the NUREG-0661 criteria as it relates to the design adequacy of the Hope Creek internal structures is therefore considered to be met.

4-3.0 LIST OF REFERENCES

1. "Mark I Containment Long-Term Program," Safety Evaluation Report, Nuclear Regulatory Commission, NUREG-0661, July 1980.

2. "Mark I Containment Program Load Definition Report," General Electric Company, NEDO-21888, Revision 2, December 1981.

3. "Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide," Task Number 3.1.3, General Electric Company, NEDO-24583-1, October 1979.

4. ASME Boiler and Pressure Vessel Code, Section III, Division 1, 1977 Edition with Addenda up to and including Summer 1977.