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DRESDEN NUCLEAR POWER STATION
UNITS 2 AND 3
PLANT UNIQUE ANALYSIS REPORT
VOLUME 4
INTERNAL STRUCTURES ANALYSIS

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4-iii-4-viii	0	DCT	MDP	N/A	4-3.1	0	DCT	MDP	IDMcI
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4-2.1-4-2.15	↓	DCT	MDP	IDMcI		↓			
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ABSTRACT

The primary containments for the Dresden Nuclear Power Station Units 2 and 3 were designed, erected, pressure-tested, and N-stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section III, 1965 Edition with addenda up to and including Winter 1965 for the Commonwealth Edison Company (CECo) by the Chicago Bridge and Iron Company. Since then, new requirements have been established. These requirements affect the design and operation of the primary containment system and are defined in the Nuclear Regulatory Commission's (NRC) Safety Evaluation Report, NUREG-0661. This report provides an assessment of containment design loads postulated to occur during a loss-of-coolant accident or a safety relief valve discharge event. In addition, it provides an assessment of the effects that the postulated events have on containment systems operation.

This plant unique analysis report (PUAR) documents the efforts undertaken to address and resolve each of the applicable NUREG-0661 requirements. It demonstrates that the design of the primary containment system is adequate and that original design safety margins have been restored, in accordance with NUREG-0661 acceptance criteria. The Dresden Units 2 and 3 PUAR is composed of the following seven 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 LINE PIPING ANALYSIS

- o Volume 6 - TORUS ATTACHED PIPING AND SUPPRESSION CHAMBER PENETRATION ANALYSES (DRESDEN UNIT 2)
- o Volume 7 - TORUS ATTACHED PIPING ANALYSIS AND SUPPRESSION CHAMBER PENETRATION ANALYSES (DRESDEN UNIT 3)

This volume documents the evaluation of the suppression chamber internal structures. Volumes 1 through 4 and 6 and 7 have been prepared by NUTECH Engineers, Incorporated (NUTECH), acting as an agent to the Commonwealth Edison Company. Volume 5 has been prepared by Sargent and Lundy, who performed the safety relief valve discharge line (SRVDL) piping analysis. Volume 5 describes the methodology and procedures used in the SRVDL piping analysis.

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LIST OF ACRONYMS

ASME	American Society of Mechanical Engineers
CO	Condensation Oscillation
DBA	Design Basis Accident
ECCS	Emergency Core Cooling System
IBA	Intermediate Break Accident
IR	Inside Radius
LDR	Load Definition Report
LOCA	Loss-of-Coolant Accident
NRC	Nuclear Regulatory Commission
NVB	Non-Vent Line Bay
OBE	Operating Basis Earthquake
PUAAG	Plant Unique Analysis Applications Guide
PUAR	Plant Unique Analysis Report
PULD	Plant Unique Load Definition
SRV	Safety Relief Valve
SSE	Safe Shutdown Earthquake
VB	Vent Line Bay

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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 (Reference 1) which affect the Dresden Units 2 and 3 internal structures. The internal structures PUAR is organized as follows:

- INTRODUCTION
  - Scope of Analysis
  - Summary and Conclusions
- INTERNAL STRUCTURES ANALYSIS (Catwalk and Electrical Conduits)
  - Component Description
  - Loads and Load Combinations
  - Acceptance Criteria
  - Methods of Analysis
  - Analysis Results

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.

4.1.1 Scope of Analysis

The criteria presented in Volume 1 are used as the basis for all of the Dresden Units 2 and 3 internal structures evaluations described in this volume. The internal structures evaluated are the catwalk and electrical conduits. These structures are not required for the safe operation of the primary containment system during accident conditions.

These internal structures are evaluated for the effects of loss-of-coolant accident (LOCA) and safety relief valve (SRV) discharge-related loads, as defined by the Nuclear Regulatory Commission's (NRC) Safety Evaluation Report, NUREG-0661 and the "Mark I Containment Program Load Definition Report" (LDR) (Reference 2).

The LOCA and SRV discharge loads used in this evaluation are formulated using the procedures discussed in Volume 1 of this report. The evaluation includes a structural analysis 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 PUAAG and the American Society of Mechanical Engineers (ASME) Code (Reference 4) to ensure that safety-related components are not adversely affected.

Other internal structures evaluated were the vent line drain, thermowells, and the emergency core cooling system (ECCS) suction strainers. They are described in Sections 2-2.1, 3-2.1, 6-2.1, and 7-2.1 respectively.

4-1.2 Summary and Conclusions

The evaluation documented in this volume is performed for the Dresden Units 2 and 3 internal structures identified in Section 1-1.1 and described in Section 1-2.1. These structures are the catwalk and electrical conduits.

The LOCA and SRV discharge-related events defined in NUREG-0661 result in hydrodynamic loadings on the internal structures. The major loadings which affect the catwalk and electrical conduits above the suppression pool include pool swell impact and drag loads, froth impingement loads, and pool fallback loads. The major loadings which affect submerged portions of the catwalk include submerged structure loadings. Conservative values for these loadings are developed using the methodology discussed in Section 1-4.0. Other loads such as dead weight and seismic loads have a lesser effect on the internal structures, but are also considered in the evaluation.

The analysis results for these loadings are used to formulate the controlling event combinations which affect the internal structures, as discussed in Section 1-3.2. The results are compared to acceptance limits which ensure that the internal structures do not fail and result in damage to safety-related components. The evaluation results show that the stresses for all of the internal structures are within acceptable limits. The NUREG-0661 requirements are therefore considered to be met.

4-2.0 INTERNAL STRUCTURES ANALYSIS

An evaluation of each of the NUREG-0661 requirements which affect the design adequacy of the Dresden Units 2 and 3 internal structures is presented in the following sections. The criteria used in the evaluation are contained in Volume 1 of this report.

The internal structures components 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 acceptance limits to which the analysis results are compared are discussed and presented in Section 4-2.3. The analysis methodology used to evaluate the effects of these loads and load combinations is discussed in Section 4-2.4. 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 electrical conduits, which are described in Sections 4-2.1.1 and 4-2.1.2, respectively.

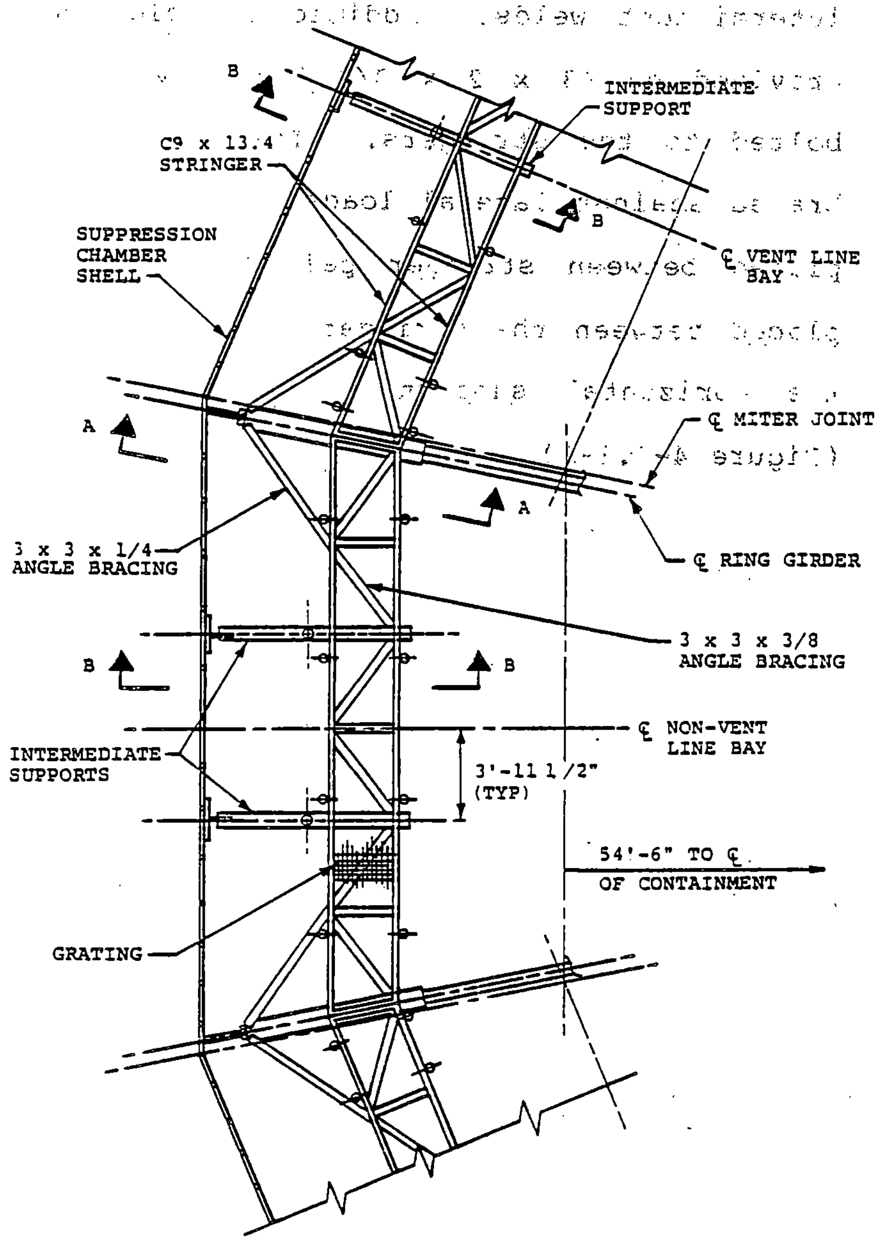
4-2.1.1 Catwalk

The catwalk is a platform-type structure, approximately three 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 C9 x 13.4 stringers, which extend from ring girder to ring girder. The catwalk frame is supported at two intermediate locations between ring girders in the non-vent line bays (NVB) and at one intermediate location in the vent line bays (VB) (Figure 4-2.1-1). The supports at the ring girders consist of a W12 x 136 horizontal support beam attached to a 6" XXS vertical pipe column (Figure 4-2.1-2). The intermediate supports consist of a W16 x 36 horizontal support beam attached to a 4", Schedule 120, vertical pipe strut. The pipe strut connects to a reinforcement beam which distributes the pipe strut forces to the suppression chamber shell (Figure 4-2.1-3).

The catwalk platform consists of grating that spans the stringers. The grating is attached to the stringers by

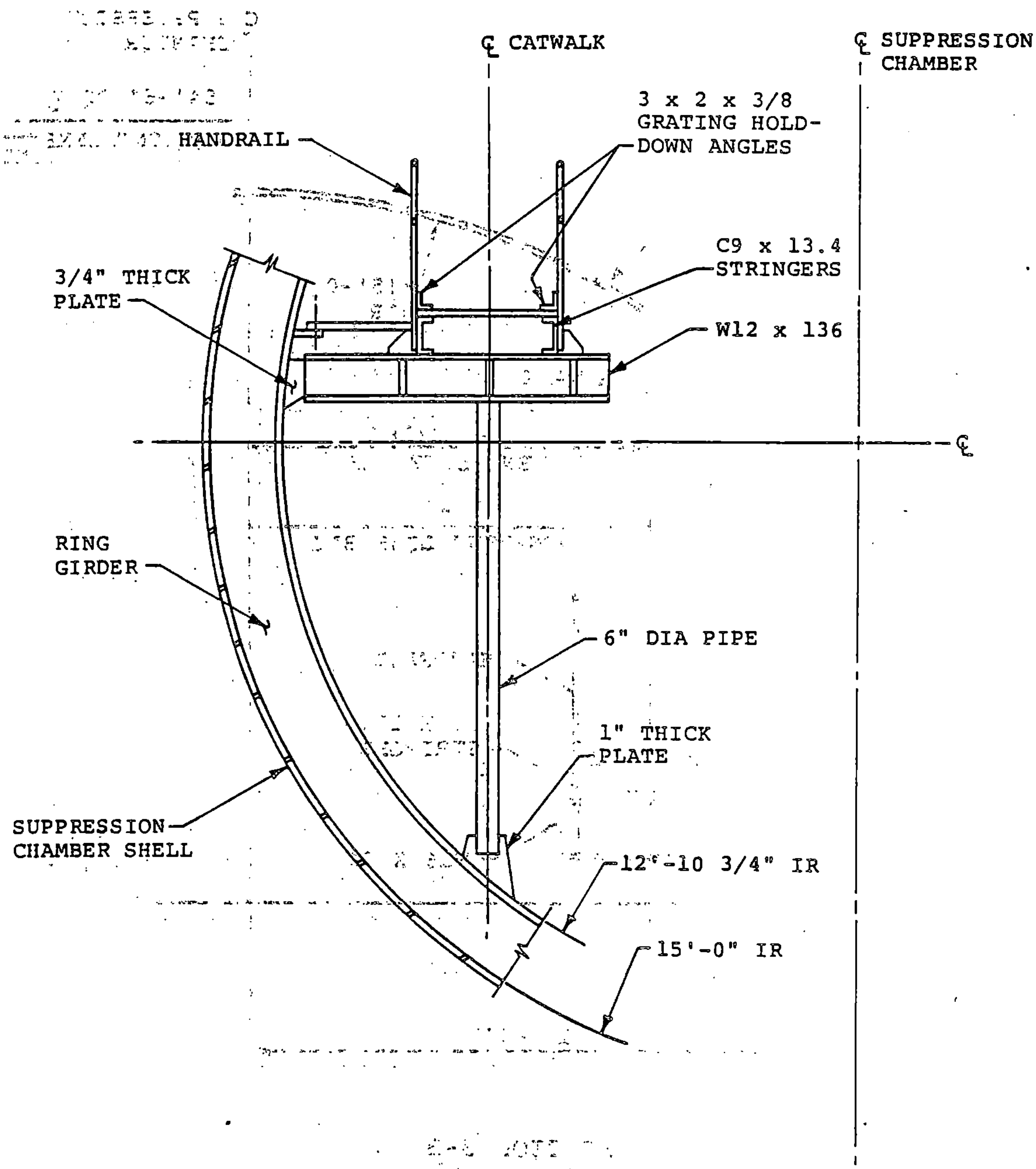
intermittent welds. Additional hold-down support is provided by L3 x 2 x 3/8 hold-down angles that are bolted to the stringers. The catwalk stringers are braced against lateral loads by: L3 x 3 x 3/8 angles placed between stringer pairs, L3 x 3 x 1/4 angles placed between the stringers and the ring girder, and the horizontal support members at the ring girders (Figure 4-2.1-1).



1. SEE FIGURE 4-2.1-2 FOR SECTION A-A.
2. SEE FIGURE 4-2.1-3 FOR SECTION B-B.

Figure 4-2.1-1

PLAN VIEW OF SUPPRESSION CHAMBER INTERNAL CATWALK

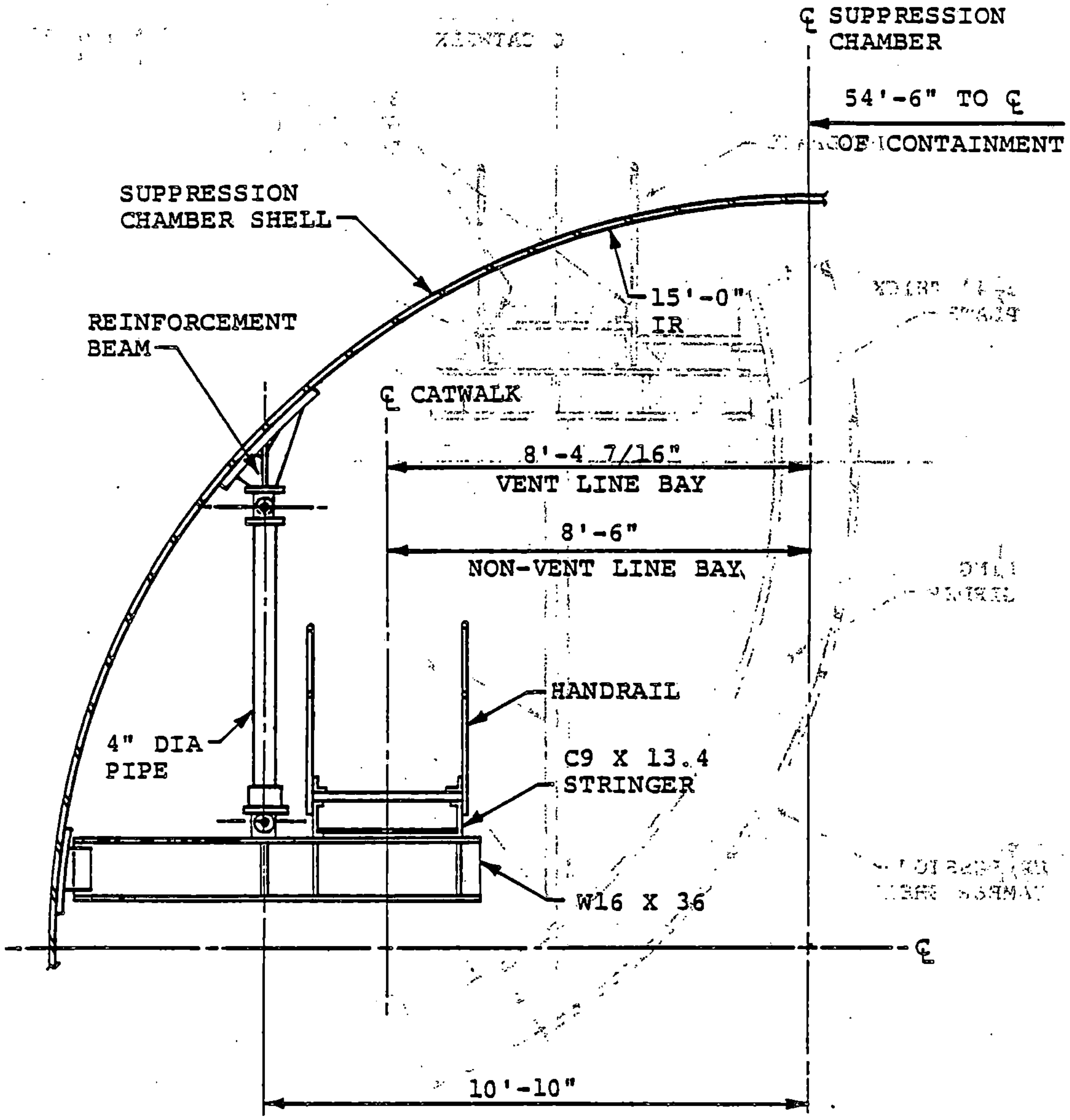


SECTION A-A

(FROM FIGURE 4-2.1-1)

Figure 4-2.1-2

SUPPRESSION CHAMBER INTERNAL CATWALK - TYPICAL SUPPORT AT MITER JOINT



SECTION B-B
(FROM FIGURE 4-2.1-1)

Figure 4-2.1-3

SUPPRESSION CHAMBER INTERNAL CATWALK - TYPICAL SUPPORT BETWEEN MITER JOINTS

4-2.1.2 Electrical Conduits

Electrical outlets are placed along the catwalk for use by maintenance personnel during outages. Wiring for the electrical outlets is routed through 3/4" and 1-1/4" flexible conduits. The conduits are attached to short, vertical members that are welded to the web of the catwalk stringers. Junction boxes at the connection and termination points of the conduit are also supported on short, vertical members that are welded to the web of the stringers.

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4-2.2 Loads and Load Combinations

The loads for which the Dresden Units 2 and 3 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
   a. Dead Weight of Steel
2. Seismic Loads
   a. Operating Basis Earthquake (OBE)
   b. Safe Shutdown Earthquake (SSE)
3. Pool Swell Loads
   a. Pool Swell Impact and Drag
   b. Froth Impingement and Fallback
   c. Pool Fallback
   d. LOCA Bubble-Induced Drag on Submerged Structures
4. Condensation Oscillation (CO) Loads
   a. Design Basis Accident (DBA) CO Drag on Submerged Structures
   b. Intermediate Break Accident (IBA) CO Drag on Submerged Structures
5. Chugging Loads
   a. Pre-Chug Drag on Submerged Structures
   b. Post-Chug Drag on Submerged Structures

6. Safety Relief Valve Discharge Loads

   a. SRV Discharge Bubble-Induced Drag on Submerged Structures

7. Containment Interaction Loads

   a. Suppression Chamber Motions

Table 4-2.2-1 shows the specific loads that affect the catwalk and conduit. 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 Volumes 2 and 3 of this report.

Table 4-2.2-1

INTERNAL STRUCTURES

COMPONENT LOADING IDENTIFICATION

VOLUME 4 LOAD DESIGNATION		CATWALK	ELECTRICAL CONDUITS	PUAR VOLUME SECTION REFERENCE
CATEGORY	CASE NUMBER			
DEAD WEIGHT	1a	X	X	1-3.1
SEISMIC	2a	X	X	1-3.1
	2b	X	X	1-3.1
POOL SWELL LOADS	3a	X	X	1-4.1.4.2
	3b	X		1-4.1.4.3
	3c	X	X	1-4.1.4.4
	3d	X (1)		1-4.1.6
CONDENSATION OSCILLATION	4a	X (1)		1-4.1.7.3
	4b	X (1)		1-4.1.7.3
CHUGGING	5a	X (1)		1-4.1.8.3
	5b	X (1)		1-4.1.8.3
SRV DISCHARGE	6a	X (1)		1-4.2.4
CONTAINMENT INTERACTION	7a	X		VOLUME 2

(1) APPLIES TO SUPPORT COLUMN AT THE RING GIRDER ONLY.

4-2.2.2 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 electrical conduits and a majority of the internal catwalk components are located above or below the pool surface, the event combinations that produce controlling stresses are those which contain pool swell and SRV discharge loads.

The submerged portions of the catwalk supports are subjected to LOCA air clearing, condensation oscillation, chugging, and SRV discharge submerged structure loads identified in Section 1-4.0. The catwalk is evaluated for two controlling combinations. These are the IBA 15 and the DBA 25 combinations as described in the PUAAG (Table 4-2.2-2). The electrical conduits and junction boxes are evaluated for the controlling DBA 25 combination, since the pool swell load is the dominant load on these components.

Table 4-2.2-2

INTERNAL STRUCTURES CONTROLLING LOAD COMBINATIONS

LOAD DESIGNATION[1]		LOAD COMBINATION 15[2]	LOAD COMBINATION 25[2]
DEAD WEIGHT		1	1
SEISMIC	OPERATING BASIS EARTHQUAKE		
SEISMIC	SAFE SHUTDOWN EARTHQUAKE	2b	2b
POOL SWELL			3a-3d
CONDENSATION OSCILLATION[3]		4b	
CHUGGING[3]		5a-5b	
SRV DISCHARGE[3]		6	6
CONTAINMENT INTERACTION		7	7
SERVICE LEVEL AT WHICH STRESSES ARE EVALUATED	TORUS SHELL	B[4]	C
SERVICE LEVEL AT WHICH STRESSES ARE EVALUATED	CATWALK AND ELECTRICAL CONDUITS	E[5]	E[5]

(1) SEE PUAR SECTION 4-2.2.1.

(2) SEE NUREG-0661.

(3) SUBMERGED STRUCTURE LOADINGS ONLY AFFECT SUBMERGED PORTIONS OF CATWALK COLUMN SUPPORTS.

(4) THE CONTROLLING LOAD COMBINATION FOR THE TORUS SHELL AT CATWALK ATTACHMENT LOCATIONS IS THE DBA 18 COMBINATION AS DESCRIBED IN REFERENCE 3.

(5) THE CATWALK IS CONSERVATIVELY ANALYZED TO SERVICE LEVEL D LIMITS.

4-2.3 Acceptance Criteria

Table 4-2.2-2 shows the service level assignments for the internal structures and the suppression chamber shell at attachment points to internal structures. The table shows that the catwalk and electrical conduits 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 catwalk is 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 of the catwalk components for the controlling combination are presented in Section 4-2.5. The electrical conduits are evaluated to ensure that they will not impair the function of safety-related components.

4-2.4 Methods 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. An equivalent static analysis is performed for all catwalk loadings except for containment interaction and pool swell loads, for which transient analysis is performed. The transient analysis of the catwalk is performed using a beam finite element model which includes the stringers, hangers, and associated catwalk components. The reaction loads from the catwalk pipe strut to the suppression chamber are obtained from the bounding load combination for the attachment points. The results from a unit load case on a finite element model composed of plate elements, which represents a 90° section of the suppression chamber shell and the reinforcement beam, are factored by the reaction loads from the catwalk. The resulting stresses in the suppression chamber shell are combined with the stresses obtained from the suppression chamber analysis to evaluate local stresses in the suppression chamber shell. Volume 2 of this PUAR describes the suppression chamber analysis and the general state of stress 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. Table 4-2.5-1 shows the resulting maximum stresses for the catwalk for the controlling load combination. This table shows that the calculated stresses for these components are less than the corresponding allowable stresses. Table 4-2.5-2 shows the state of stress in the suppression chamber shell at the catwalk reinforcement beam locations.

The results of the electrical conduit supports and junction boxes confirm that the conduits will not impair the function of any safety-related components.

Table 4-2.5-1

CATWALK STRESSES FOR CONTROLLING LOAD COMBINATIONS

ITEM	MATERIAL	MATERIAL PROPERTIES (ksi)	BEAM STRESS TYPE	LOAD COMBINATION STRESSES (ksi) DBA 25 CALCULATED STRESS (3)	ALLOWABLE STRESS (SERVICE LEVEL D)	CALCULATED / ALLOWABLE (1)
STRINGER	ASTM A-36	$S_y = 36.0$ (2) $S_u = 58.0$	SHEAR	2.56	12.84 (2)	0.99
			BENDING	37.97	43.20 (2)	
SUPPORT BEAM AT MITER JOINT	ASTM A-36	$S_y = 32.1$ $S_u = 58.0$	SHEAR	0.76	25.68	0.04
			BENDING	1.87	42.38	
SUPPORT COLUMN AT MITER JOINT	ASME SA-333 GRADE 6	$S_y = 31.2$ $S_u = 60.0$	COMPRESSIVE	1.25	30.00	0.07
			BENDING	1.22	41.18	
INTERMEDIATE SUPPORT BEAM	ASTM A-36	$S_y = 32.1$ $S_u = 58.0$	SHEAR	7.27	25.68	0.49
			BENDING	19.09	38.65	
INTERMEDIATE PIPE STRUT	ASTM A-333 GRADE 6	$S_y = 26.7$ $S_u = 55.0$	COMPRESSIVE	9.89	27.52	0.63
			BENDING	8.86	35.24	
ANGLE BRACING	ASTM A-36	$S_y = 36.0$ (2) $S_u = 58.0$	COMPRESSIVE	14.91	28.00 (2)	0.86
			BENDING	13.31	43.20 (2)	

(1) VALUES SHOWN ARE OBTAINED FROM BEAM INTERACTION EQUATION.

(2) VALUES CONSIDERED ARE FOR ACTUAL TEMPERATURE.

(3) TIME PHASING OF THE RESPONSE IS NOT CONSIDERED. THE PEAK-TO-PEAK VALUES ARE CONSERVATIVELY USED.

Table 4-2.5-2

MAXIMUM SUPPRESSION CHAMBER SHELL STRESSES AT CATWALK REINFORCEMENT BEAM LOCATIONS

STRESS TYPE	CALCULATED STRESS (ksi)	CALCULATED ALLOWABLE
PRIMARY MEMBRANE	11.94	0.41
LOCAL PRIMARY MEMBRANE	24.72	0.85
PRIMARY + SECONDARY STRESS RANGE	59.74	0.86

4-2.5.1 Closure

The values of the loads used to evaluate the internal structures are conservative estimates of the loads postulated to occur during an actual LOCA or SRV discharge event. The event combinations for which the internal structures are evaluated envelop the actual events expected to occur during a LOCA or SRV discharge 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 structures will not fail and cause damage to safety-related components.

The analysis results presented show that stresses in the internal structure components are within these conservative acceptance limits. The NUREG-0661 criteria are therefore considered to be met.

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The analysis results presented show that stresses in the internal structure components are within these conservative acceptance limits. The NUREG-0661 criteria are 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; Supplement 1, August 1982.

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

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

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