ABB

February 22, 1994
LD-94-012

Docket No. 52-002

Attn: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: System 80+™ Information for Issue Closure

Dear Sirs:

The attachments to this letter provide material to close follow-on questions to DSER responses. Attachment 1 provides minor revisions to Section 1.4 of CESSAR-DC in response to a comment from Mr. T. Boyce.

Attachment 2 transmits a revision to Table 3.9-15 as requested from and faxed to Mr. C. Li on January 11, 1994.

Attachment 3 presents a copy of information on the Containment Spray and Shutdown Cooling Systems which was faxed to Mr. S. Sun on February 2, 1994.

Attachment 4 provides a revision to Appendix 5E on the Intersystem LOCA issue which was previously faxed to Mr. D. Terao.

Attachment 5 transmits a revision to Section 9.5.3 on emergency lighting which was requested by Mr. C. Thomas.

Attachment 6 transmits a revision to Section 12.3.1 to address a comment from the ACRS on cobalt content of materials in contact with the reactor coolant. This revision should be given to Mr. C. Hinson.

Attachment 7 provides a revision to Section 14.2.12 which addresses a confirmatory item on relief valve bench testing.

Attachment 8 presents a response to the issue on Safety Injection pump durability under mini-flow conditions (Section 6.3). This information was faxed to NRC on January 14, 1994, and should be given to Mr. T. Collins.

070077

ABB Combustion Engineering Nuclear Power

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1000 Prospect Hill Rd
Windsor, CT 06095
Telephone (203) 688-1911
Fax (203) 285-5203

D032
1/1

Attachment 9 transmits a copy of a fax to Mr. N. Saltos on fire protection inside containment.

Attachment 10 transmits a revision to the System 80+ Fire Hazards Assessment to make it consistent with CESSAR-DC, Amendment U revisions to which the NRC staff has agreed. A corresponding change to Section 1.6 is also included.

Attachment 11 transmits revisions to Chapters 2 and 3 which have been previously provided as a result of meetings with NRC staff. Attachment 12 provides corresponding changes to Chapters 1 and 19. Changes to the Seismic Margins Assessment of Chapter 19 will be provided within the next few days, along with other Chapter 19 changes.

Attachment 13 provides a revised copy of the Software Program Manual for Nuplex 80+ to address a comment from the ACRS. The revision, in Section 9 of the manual, has been discussed and agreed to by NRC staff.

CESSAR-DC changes provided above will be printed in Amendment V. In addition to the above revisions, the Severe Accident Mitigation Design Alternatives analysis in Appendix 19A will be revised to be consistent with data in Amendment U. It is understood that the revision to Appendix 19A will not significantly change any result or NRC staff conclusion.

If you have any questions, please call me or Mr. Stan Ritterbusch at (203) 285-5206.

Very truly yours,

COMBUSTION ENGINEERING, INC.

C B Brinkman

C. B. Brinkman
Acting Director
Nuclear Systems Licensing

CBB/ser
cc: J. Trotter (EPRI)
T. Wambach (NRC)
P. Lang (DOE)

ATTACHMENT 1

1.4 IDENTIFICATION OF AGENTS AND CONTRACTORS

1.4.1 APPLICANT'S QUALIFICATIONS AND EXPERIENCE

(Presented in site-specific SAR.)

1.4.2 ARCHITECT-ENGINEER'S QUALIFICATIONS AND EXPERIENCE

(Presented in site-specific SAR.)

1.4.3 COMBUSTION ENGINEERING'S QUALIFICATIONS AND EXPERIENCE

Combustion Engineering, Inc. (hereafter referred to as C-E, Combustion, ABB Combustion Engineering Nuclear Power or ABB-CE) nuclear power activities are of three general types: design, development, construction and operation of reactor and auxiliary systems; design and fabrication of nuclear components; and, support of design, development and analytical projects.

A summary of the company's efforts, accomplishments, and operating experience in the light water reactor field is provided below.

1.4.3.1 Pre-Commercial Reactor Programs

1.4.3.1.1 Naval Propulsion Program

During the period 1955 through 1960, Combustion was a major contributor to the U.S. Naval Reactors program. The Company designed and built, at its Windsor, Connecticut site, the prototype of a small attack submarine power plant. This prototype (S1C) went into operation in 1959 and ~~is still being~~ was operated as a naval training facility. A second plant of this type was also designed and built by Combustion for installation in the USS Tullibee (SSN-597) which has been operated as a part of the United States nuclear submarine fleet.

In the design, development, construction and operation of the prototype system and the submarine power plant, Combustion's responsibilities included all safety aspects of the reactor systems.

1.4.3.1.2 Boiling Nuclear Superheat (BONUS) Plant

Combustion was responsible for the nuclear design and for the direction of startup and initial operation of the BONUS plant in Puerto Rico.

The design of this reactor system presented a number of unique problems, e.g., control and safety analysis of a two-region core, design of a superheater fuel element, design of a steam control system to assure adequate cooling of superheater fuel under all credible conditions, and design of a containment building of the "total containment" type to house the entire power generating installation.

The BONUS plant achieved full power operation in September 1965, and was the first nuclear power plant under USAEC control operating with an integral superheating core.

1.4.3.2 Development and Design of Commercial PWR Systems

The development and design by Combustion of a pressurized water reactor for utility service dates back to 1958. At that time, the Company was selected by the AEC to undertake the design, analysis and economic evaluation of a 250 MWe PWR plant, in conjunction with an architect-engineer. This effort provided initial technical and economic guidelines for Combustion's commercial development of the PWR.

With a subsequent decision by the Company to concentrate on the development of the PWR for large nuclear power stations, a program was initiated to guide required design and development work along appropriate lines. The following is representative of the types of PWR-oriented work which have been performed:

A. Evaluation of overall plant and systems to establish optimum physical arrangement and design criteria from the standpoint of economics and safety. Much of this work has been performed in conjunction with qualified architect-engineering organizations;

B. Design and development of nuclear components such as control element assemblies, control element assembly drive mechanisms, and auxiliary systems equipment.

C. Extensive testing of PWR nuclear components, such as fuel assemblies and reactor control components, under actual service pressure, temperature and flow conditions.

Combustion Engineering's Nuclear Laboratories have been engaged in the development and testing of fuels, fuel elements, control assemblies, reactor components and materials for reactor application. Particular emphasis has been given to UO_2 and Zircaloy cladding technology, involving both in-pile and out-of-pile investigations. The initial efforts in the laboratories were associated with submarine reactor programs. Beginning in ~~Since~~ 1960, the personnel of the nuclear laboratories ~~have~~ actively participated in the joint U.S. AEC - Euratom research and development program for fuels development. In addition to these programs, personnel in the Nuclear Laboratories have been responsible for materials design activities for the HWOCR study and for pressurized water, boiling water, nuclear superheat, and fast breeder reactor systems.

1.4.3.3 **Major Component Design and Fabrication**

During the period of 1955-1961, Combustion Engineering (C-E) was a major supplier of nuclear cores for naval propulsion service. C-E has fabricated the boiling and the superheating fuel for the BONUS reactor. The boiling section of the Bonus core was made up of Zircaloy clad, rod type, UO_2 fuel elements fundamentally similar to those being utilized in the C-E Standard fuel design. The superheater fuel utilizes Inconel-clad, rod type, UO_2 fuel elements. The superheater cladding is designed for an operating temperature of 1250°F.

Combustion Engineering has performed (or will perform) the design engineering and fabrication of control rod drive mechanisms and fuel rods for all of the commercial power reactors listed in Table 1.4-1.

Combustion Engineering has fabricated and shipped many reactor vessels for utility plant service and for naval service. Additional vessels for plant sizes up through 1300 Mwe are now in service.

Combustion Engineering has fabricated nuclear steam generators for naval service and for all its commercial PWR plants. In addition, the company designed and fabricated the 10 steam generators in the Hanford Production Reactor facility.

Combustion Engineering manufactures reactor vessel internal structures and reactor coolant pump components at its Newington, N.H. facility.

~~Combustion Engineering extended its manufacturing capability to include fabrication of reactor coolant pumps by its entry in 1974 into joint ownership of the CE/KSB Pump Company.~~

1.4.3.4 **Facilities**

The C-E laboratories at Windsor, Connecticut, and Chattanooga, Tennessee, provide complete facilities for the development, design, analysis and testing of PWR components and systems. These laboratories include equipment for:

A. Mechanical Testing.

B. X-ray and Radiography.

C. Metallography.

D. Ceramics Development.

E. Analytical and Radio-Chemistry

F. Fuel Fabrication Development

G. Corrosion Testing

H. 2500 psi Component Performance Testing

I. 2500 psi and 5000 psi Steam Generation

J. Welding Development.

C-E maintains a fuel manufacturing facility in Hematite, Missouri. The Hematite plant ~~is used to~~ converts UF_6 gas to UO_2 powder, and makes fuel pellets from the UO_2 for use in the fuel fabrication process. ~~The pellets are then shipped to Windsor, Connecticut to complete the fuel fabrication process, as described below. Currently, the Hematite facility is completing a multi-million dollar improvement program to modernized manufacturing operations. In the near future C-E will transfer all fuel fabrication activities to the Hematite plant.~~

element

The Windsor facilities of Combustion Engineering, Inc. are equipped to fabricate, and provide the necessary quality control for, f~~uel assemblies,~~ control assemblies, control assembly drive mechanisms, and other specialized nuclear components. element

Combustion Engineering's Chattanooga Plant includes a separate facility to design, fabricate, and provide quality control for large reactor pressure components. The facility has such special equipment as heavy duty cranes and large capacity machine tools capable of performing work on large, heavy parts to close tolerances and fine surface finishes. It is also equipped with the latest testing and quality control equipment, including a linear accelerator for weld examination.

1.4.3.5 Commercial Reactor Operation

Table 1.4-1 lists all Combustion Engineering Pressurized Water Reactors designed and built to date.

TABLE 1.4-1

(Sheet 1 of 2)

C-E PRESSURIZED WATER REACTOR PLANTS

Plant	Operator Utility	Plant Location	Commercial Operation	Nominal Mwe Net
Non-System 80 Plants				
Palisades	Consumers Power Co.	Michigan	1972	800
Maine Yankee	Maine Yankee Atomic Power Co.	Maine	1972	800
Fort Calhoun	Omaha Public Power District	Nebraska	1973	475
Calvert Cliffs Unit 1	Baltimore Gas & Electric Co.	Maryland	1974	850
Millstone Point Unit 2	Northeast Utilities	Connecticut	1975	865
Calvert Cliffs Unit 2	Baltimore Gas & Electric Co.	Maryland	1976	850
St. Lucie Unit 1	Florida Power & Light Co.	Florida	1976	810
Arkansas Nuclear One Unit 2	Arkansas Power & Light Co.	Arkansas	1980	900
St. Lucie Unit 2	Florida Power & Light Co.	Florida	1983	810
San Onofre Unit 2	Southern California Edison Co.	California	1983	1100
San Onofre Unit 3	Southern California Edison Co.	California	1984	1100
Waterford Unit 3	Louisiana Power & Light Co.	Louisiana	1985	1100

A

TABLE 1.4-1 (Cont'd)

(Sheet 2 of 2)

C-E PRESSURIZED WATER REACTOR PLANTS

Plant	Operator Utility	Plant Location	Commercial Operation	Nominal Mwe Net	
System 80 Plants					
Palo Verde Nuclear Generating Station	Arizona Public Service Company	Arizona		1300	A
Units 1			1986		
2			1986		B
3			1988		
Washington Nuclear Project Unit 3	Washington Public Power Supply System	Washington		1300	A
					E
Yonggwang	Korea Electric Power Company	Republic of Korea		1000	
Units 3			199~~4~~5*		B
4			199~~5~~6*		
Ulchin	Korea Electric Power Company	Republic of Korea		1000	A
Units 3			1998*		
4			1999*		

* Anticipated Commercial Operation

ATTACHMENT 2

Ref: DSER Open Item 6.2.6-2

TABLE 3.9-15 (Sheet 1 of 80)

INSERVICE TESTING SAFETY-RELATED PUMPS AND VALVES

Pump	Safety Class	(h) Test Parameter	Test Freq	(i) Test Config.	CESSAR-DC Figure No.
CCW PUMP 1A	3	DP,SP_S,SP_O,~~Q~~,V Q_1, Q_2	3 mo.	16	9.2.2-1.1
CCW PUMP 1B	3	DP,SP_S,SP_O,~~Q~~,V	3 mo.	16	9.2.2-1.1
CCW PUMP 2A	3	DP,SP_S,SP_O,~~Q~~,V	3 mo.	16	9.2.2-1.7
CCW PUMP 2B	3	DP,SP_S,SP_O,~~Q~~,V	3 mo.	16	9.2.2-1.7
MD EFW PUMP 1	3	DP,SP_S,SP_O,Q,V	3 mo.	21	10.4.9-1.1
TD EFW PUMP 1	3	N,DP,SP_S,SP_O,Q,V	3 mo.	21	10.4.9-1.1
MD EFW PUMP 2	3	DP,SP_S,SP_O,Q,V	3 mo.	21	10.4.9-1.1
TD EFW PUMP 2	3	N,DP,SP_S,SP_O,Q,V	3 mo.	21	10.4.9-1.1
SI PUMP 1	2	DP,SP_S,SP_O,Q,V(46)	3 mo.	18	6.3.2-1A
SI PUMP 2	2	DP,SP_S,SP_O,Q,V(46)	3 mo.	18	6.3.2-1B
SI PUMP 3	2	DP,SP_S,SP_O,Q,V(46)	3 mo.	18	6.3.2-1A
SI PUMP 4	2	DP,SP_S,SP_O,Q,V(46)	3 mo.	18	6.3.2-1B
SC PUMP 1	2	DP,SP_S,SP_O,Q,V	3 mo.	19	6.3.2-1A
SC PUMP 2	2	DP,SP_S,SP_O,Q,V	3 mo.	19	6.3.2-1B
CS PUMP 1	2	DP,SP_S,SP_O,Q,V	3 mo.	19	6.3.2-1A
CS PUMP 2	2	DP,SP_S,SP_O,Q,V	3 mo.	19	6.3.2-1B
SSW PUMP 1A	3	DP,SP_C,Q,V	3 mo.	17	9.2.2-1.1
SSW PUMP 1B	3	DP,SP_C,Q,V	3 mo.	17	9.2.2-1.1
SSW PUMP 2A	3	DP,SP_C,Q,V	3 mo.	17	9.2.1-1.3
SSW PUMP 2B	3	DP,SP_C,Q,V	3 mo.	17	9.2.1-1.3
ECW PUMP 1A	3	DP,SP_S,SP_O,Q,V	3 mo.	20	9.2.9-1.1
ECW PUMP 1B	3	DP,SP_S,SP_O,Q,V	3 mo.	20	9.2.9-1.1
ECW PUMP 2A	3	DP,SP_S,SP_O,Q,V	3 mo.	20	9.2.9-1.5
ECW PUMP 2B	3	DP,SP_S,SP_O,Q,V	3 mo.	20	9.2.9-1.5
DG BUILDING SUMP PUMP 1A	3	DP,SP_C,Q,V	3 mo.	17	9.5.9-1
DG BUILDING SUMP PUMP 1B	3	DP,SP_C,Q,V	3 mo.	17	9.5.9-1
DG BUILDING SUMP PUMP 2A	3	DP,SP_C,Q,V	3 mo.	17	9.5.9-1
DG BUILDING SUMP PUMP 2B	3	DP,SP_C,Q,V	3 mo.	17	9.5.9-1
RB SUBSPHERE QUAD A SUMP PUMP 1	3	DP,SP_C,Q,V	3 mo.	17	9.3.3-2.1
RB SUBSPHERE QUAD A SUMP PUMP 2	3	DP,SP_C,Q,V	3 mo.	17	9.3.3-2.1
RB SUBSPHERE QUAD B SUMP PUMP 1	3	DP,SP_C,Q,V	3 mo.	17	9.3.3-2.2
RB SUBSPHERE QUAD B SUMP PUMP 2	3	DP,SP_C,Q,V	3 mo.	17	9.3.3-2.2
RB SUBSPHERE QUAD C SUMP PUMP 1	3	DP,SP_C,Q,V	3 mo.	17	9.3.3-2.1
RB SUBSPHERE QUAD C SUMP PUMP 2	3	DP,SP_C,Q,V	3 mo.	17	9.3.3-2.1
RB SUBSPHERE QUAD D SUMP PUMP 1	3	DP,SP_C,Q,V	3 mo.	17	9.3.3-2.2
RB SUBSPHERE QUAD D SUMP PUMP 2	3	DP,SP_C,Q,V	3 mo.	17	9.3.3-2.2
SPENT FUEL POOL COOLING PUMP 1	3	DP,SP_S,SP_O,Q,V	3 mo.	20	9.1.3
SPENT FUEL POOL COOLING PUMP 2	3	DP,SP_S,SP_O,Q,V	3 mo.	20	9.1.3

Ref: DSER Open Item 6.2.6-2

TABLE 3.9-15 (Sheet 80 of 80)

INSERVICE TESTING SAFETY-RELATED PUMPS AND VALVES

range of the pump, and RPM measurements are taken to demonstrate pump speed control settings correspond with the actual pump RPM.

Add Insert 40 ~~(40) Valves: SI-390, SI-391, SI-392, SI-393~~

~~These valves must open in a severe accident to allow water in the IRWST to flood the reactor cavity to cover core debris. To test these valves, manual valves upstream must be closed to prevent flow of water from the IRWST to the Holdup Volume Tank when these valves are opened. Closing the manual valves is not practical during operations since they require containment entry Therefore, these valves will be tested during cold shutdown.~~

(41) Valves: SI-612, SI-622 , SI-632 , SI-642 , SI-619, SI-629, SI-639, SI-649

These air-operated SIT Nitrogen Pressure Control Valves are stroked in the course of plant operation as a matter of normal operation and pressure control of the SITs at a frequency which satisfies test requirements of quarterly testing. Fail-safe actuation (FS) on a 3 month basis, however, is impractical during plant operations (quarterly test frequency) or cold shutdown because such testing involves entries to containment to proximity of the SITs (high radiation dose and airborne contamination area) to fail air to the air diaphragm valve actuators. Therefore, the FS test for these valves will be performed on a refueling outage basis for ALARA purposes.

(42) Valves: SI-322, SI-332, SI-611, SI-618, SI-621, SI-628, SI-631, SI-638, SI-641, SI-648, SI-661, SI-670

These air-operated valves are stroked on a quarterly frequency. Fail-safe (FS) actuation testing on a 3 month basis, however ,is impractical during plant operations (quarterly test frequency) or cold shutdown because such testing involves entries to containment to proximity of the SITs (high radiation dose and airborne contamination area) to fail air to the air diaphragm valve actuators. Therefore, the FS test for these valves will be performed on a refueling outage basis for ALARA purposes.

(43) Although these Emergency Diesel Generator support system components are Safety Class 3, they are procured, tested and maintained as part of the Emergency Diesel Generators themselves, which are tested for operability and reliability by the plant Technical Specifications. Therefore, these components are tested by Technical Specifications Surveillance Requirements of Technical Specification Section 3.8.

Add Insert 46

(44) Pressure Isolation Valves (PIVs) are not reverse flow tested quarterly, since testing of these valves during power operation would require containment entries to high radiation and airborne contamination areas. PIVs are not reverse flow tested every Cold Shutdown, because of the extensive test equipment setup which could extend the Cold Shutdown. The RF function is verified, however, by leakage testing each valve in the reverse flow direction during unit startup for the testing frequency outlined in Technical Specification Surveillance Requirement 3.4.13.1. This surveillance requirement states that leakage testing of these valves is required every 18 months <u>AND</u> prior to entering Mode 2 whenever the plant has been in Mode 5 (Cold Shutdown) for 7 days or more, if leakage testing has not been performed in the previous 9 months <u>AND</u> within 24 hours following valve actuation due to automatic or manual action or flow through the valve(s).

Add Insert 45

Ref: DSER Open Item
6.2.6-2

INSERT 46 (To be inserted in CESSAR-DC Table 3.9-15 in Amendment V)

(46) For inservice testing of the safety injection pumps during refueling outages, a walkdown visual examination of safety injection system piping and components outside Containment will be conducted to verify the leak tight integrity of the system.

ATTACHMENT 3

ABB COMBUSTION ENGINEERING
NUCLEAR POWER
FAX TRANSMITTAL

To:	M.X. Franovich or T. V. Wambach Project Managers	**From:**	J. E. Robertson
		Date:	February 2, 1994
		FaxRef.:	
Company :	U. S. NRC	**Company:**	ABB C-E
Dept:	Standardization Project Directorate	**Dept:**	Fluid Systems Engineering
Phone:	301-504-1121/1103	**Phone:**	(203) 285-4688
Fax:	301-504-2260	**Fax:**	(203) 285-3267

This page with 4 pages to follow.

Mike/Tom,

Attached are marked-up pages from CESSAR DC Tables 5.4.7-2 and 6.5-3, in response to verbal questions from Mr. Summer Sun of the Reactor Systems Branch. The questions relate to consistency between the Shutdown Cooling System and Containment Spray System Failure Modes and Effects Analyses (the tables) and the system P&ID (Figures 6.3.2-1A, B, and C). Please forward this information to Summer.

These changes will be added to Amendment V. Please call me if you have any questions.

Jim Robertson

xc: S. E. Ritterbusch
F. G. Small

CESSAR-DC TABLE 5.4.7-2

ITEM 11 (SEE ATTACHED MARKUP)

a) VALVE NAME TO BE CHANGED AS NOTED
b) NOTE: VALVE NUMBERING DESIGNATION

FROM	TO:
SI-110	SI-340
SI-111	SI-342

was changed for Amendment Q

ITEM 17 (SEE ATTACHED MARKUP)

a) VALVE NAME TO BE CHANGED AS NOTED
b) NOTE: VAVE NUMBERING DESIGNATION

FROM:	TO:
SI-430	SI-341
SI-431	SI-342

was changed for Amendment Q

ITEM 18 (SEE ATTACHED MARKUP)

DELETED FROM TABLE 5.4.7-2

ADDED TO TABLE 6.5-3
(VALVES SI-454, SI-458 deleted)

SCS/CSS Pump
Suction Cross-Connect

SHUTDOWN COOLING SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

No.	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
11)	~~Containment Spray Pump Isolation~~ Valve SI-340, SI-342	a) Fails Open	Elect. Malf., mechanical binding	Loss of one SCS train	Low temperature in SCS; periodic testing, valve position indication in the control room	Redundant SCS train	Valve is normally locked closed
		b) Fails Closed	Elect. Malf., mechanical binding	No effect on SCS operation	Periodic testing, valve position indication in the control room	None required	
12)	SDCHX Inlet/Outlet Temperature Recorder T-300, T-301	a) False indication	Elect. Malf.	Inability to control cooldown rate in affected train. Possible isolation of functional SCS train	Comparison with redundant indicators, with all other process instrumentation and valve position indications consistent. Periodic testing	Redundant SCS train	

TABLE 5.4.7-2 (Cont'd)

(Sheet 7 of 7)

SHUTDOWN COOLING SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

No.	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
16)	SCS Test Return Isolation Valve SI-314, SI-315 SI-688, SI-693	a) Fails Open	Corrosion, mechanical binding	None	High temperature indication from T-300, T-301; periodic testing	Series isolation valves in IRWST return	
		b) Fails Closed	Corrosion, mechanical binding	No effect on SCS operation	Periodic testing	None required	
17)	SCS/CSS Pump ~~Crossover Valve~~ Cross-connect SI-341, SI-343	a) Fails Open	Elect. Malf., mechanical binding,	None	Periodic testing, valve position indication in the control room	CSS is normally isolated	
		b) Fails Closed	Elect. Malf., mechanical binding	No effect on SCS operation	Periodic testing, valve position indication in the control room	None required	
~~18)~~	~~PCPS Isolation Valve SI-458, SI-450, SI-455, SI-454~~	~~a) Fails Open~~	~~Mech. binding~~	~~None~~	~~Periodic testing~~	~~Redundant series valve provides isolation~~	~~Valve is normally locked closed at valve~~
		~~b) Fails Closed~~	~~Mech. binding~~	~~None~~	~~Periodic testing~~		

Amendment N
April 1, 1993

TABLE 6.5-3 (Cont'd)

(Sheet 6 of 6)

CONTAINMENT SPRAY SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

No.	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
13)	CS Pump/SCS Pump Suction Cross-Connect Valves SI-340, SI-342	a) Fails open	Corrosion, mechanical binding, operator error, electrical failure	Effective loss of one containment spray pump	Low flow indication F-338, F-348; high CS pump suction pressure indication P-310, P-320, periodic testing, valve position indicator	SCS is normally isolated	
		b) Fails closed	Corrosion, mechanical binding, electrical failure	No effect on CSS operation	Periodic testing, valve position indicator	None required	
14)	CS Pump/SCS Pump Discharge Cross-Connect Valves SI,341, SI-343	a) Fails open	Corrosion, mechanical binding, operator error, electrical failure	Effective loss of one containment spray pump	High flow indication F-338, F-348; periodic testing, valve position indicator	SCS is normally isolated	
		b) Fails closed	Corrosion, mechanical binding, electrical failure	No effect on CSS operation	Periodic testing, valve position indicator	None required	

INSERT

No.	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
15)	PCPS Isolation Valve	a) Fails Open	Mech. binding	None	Periodic testing	Blind flange ~~Redundant series valve~~ provides isolation	Valve is normally locked closed at valve
	450 454 SI-~~450~~, SI-~~458~~, ~~SI-455, SI-456~~	b) Fails Closed	Mech. binding	None	Periodic testing		

ATTACHMENT 4

Option A design features rely on inherent physical attributes of a system or subsystem which will prevent failure when it is pressurized to normal RCS operating pressure. Option A features do not require any immediate action by equipment or operators to satisfy the ISLOCA acceptance criteria. This approach is intended to provide the optimum protection against ISLOCA challenges and to allow the operator the necessary time to properly assess and restore the system to normal conditions. Examples of Option A features satisfying the ISLOCA acceptance criteria include

- locating the system or subsystem completely within containment;
- designing the system or subsystem to normal RCS design pressure;

Replace with Insert "A" next page

- designing the system or subsystem to at least 40% of the RCS normal operating pressure;
- ~~designing the system or subsystem so that the ultimate strength of the material comprising the system exceeds the stress produced in the material by pressure equal to normal RCS operating pressure; and~~ delete.
- physically separating the system or subsystem from the RCS during conditions when the RCS pressure exceeds its design pressure.

Option B design features are design responses to ISLOCA events consisting of specific equipment and instrumentation which perform actions to prevent or mitigate the consequences of an ISLOCA. Option B design responses that have been considered will not require operators to prevent or mitigate the event, but will eventually require operators to perform remedial action, inspection of equipment following the event and returning the plant systems to normal configuration.

Option B design features are intended to be applied to systems for which it is impractical to apply Option A design features.

Examples of Option B design features are

- the isolation of a system or subsystem in the pressurization pathway at the interface between the lower pressure system or subsystem and its pressurization source; and
- pressure relief to limit the pressurization to within the design capabilities of the system.

Insert "A" - Page 5E-4

Modify the third item as follows:

"• designing the system or subsystem to a pressure of at least 40% of the RCS normal pressure. Austentic Stainless Steel piping will use a minimum wall thickness corresponding to standard weight for sizes less than 16 inch NPS and schedule 40 for 16 inch NPS and larger sizes;"

ATTACHMENT 5

The design of the plant lighting systems is in accordance with applicable industry standards for illumination fixtures, cables, grounding, penetrations, conduit, and controls.

All lighting fixtures and other components of the lighting system located in normally occupied areas or in areas containing safety equipment are supported so as to enhance the earthquake survivability of these components and to ensure, in particular, that they do not present a personnel or equipment hazard when subjected to a seismic loading of a design basis earthquake.

The normal lighting system is used to provide normal illumination under all plant operation, maintenance and test conditions. Table 9.5.3-1 summarizes typical illuminance ranges for normal lighting.

The security lighting system provides the illumination required to monitor isolation zones and all outdoor areas within the plant protected perimeter. The security lighting system complies with the intent of NUREG CR-1327.

The emergency lighting system is used to provide acceptable levels of illumination throughout the station and particularly in areas where emergency operations are performed, such as control rooms, battery rooms, containment, etc., upon loss of the normal lighting system.

Lighting circuits which are connected to a Class 1E power source are treated as associated Class 1E circuits.

9.5.3.2 System Description

9.5.3.2.1 Normal Lighting System

in the main Control room and

The Normal Lighting System provides general illumination throughout the plant in accordance with illumination levels recommended by the Illuminating Engineering Society. Incandescent lighting is used in the Containment Building while incandescent, fluorescent and high intensity discharge lighting is provided in the remainder of the plant and on the plant site. Power for the Normal Lighting System is provided independently from the Normal Auxiliary Power System via dry-type transformers and lighting panelboards.

Indoor lighting is designed for continuous operation. Switching is by individual plant circuit breakers except in office areas. Outdoor lighting is controlled by photocells.

The normal lighting system is considered part of the plant permanent non-safety systems. As such, the normal lighting system is energized as long as power from an offsite power source or a standby non-safety source (Combustion Turbine) is available.

Emergency lighting in the main control room is provided such that at least two circuits of lighting fixtures are powered from different Class 1E divisions.

Normal system operation is not affected by the failure or unavailability of a single lighting transformer.

The circuits to the individual lighting fixtures are staggered as much as possible, with the staggered circuits fed from separate electrical divisions, to ensure some lighting is retained in a room in the event of a circuit failure.

9.5.3.2.2 Security Lighting System

The security lighting system is considered part of the permanent non-safety systems and is fed from the Alternate AC (AAC) Source (Combustion Turbine), which is located in a secure vital area for protection. Selected portions of the security lighting system essential to maintaining adequate plant protection are powered from a non-Class 1E battery power source.

The COL Applicant shall provide a security lighting system that will meet CCTV illumination requirements within camera viewing areas to permit prompt assessment of intrusion alarms.

The security lighting system is designed to provide a minimum illumination of 0.2 foot-candles when measured horizontally at ground level.

9.5.3.2.3 Emergency Lighting

Emergency lighting is located in vital areas throughout the plant as identified in Emergency Procedures and Hazards Analysis for safe-shutdown of the plant following an accident or hazard. Included in the vital areas will be the Control Room, Technical Support Center, Operations Support Center, the Remote Shutdown Panel Room, the stairway which provides access from the Control Room to the Remote Shutdown Panel room, Sample Room, Hydrogen Recombiner Rooms, Electrical System Areas, Main Steam Valve Houses, the Chemistry Labs, routes for personnel passage and egress, and other areas where operator access is required post-accident or hazard.

minimum

The emergency lighting system in the main control room is integrated with the normal lighting system ~~and will be configured so that normal and emergency circuits will be staggered and fed from different safety divisions to ensure that lighting is retained in the event of a circuit failure.~~ The emergency lighting system in the main control room maintains ~~adequate~~ illumination levels in the main control room during ~~all~~ emergency conditions, including station blackout. ~~The emergency lighting system in the main control room is powered from a Class 1E battery power source.~~

The emergency lighting installations which serve the main control room and other areas of the plant where safe shutdown operations may be performed are designed to remain functional during and after a design basis earthquake.

ATTACHMENT 6

Par F. Talbot 1/31/94

14.2.12.1.21 **Shutdown Cooling System Test**

1.0 OBJECTIVE

1.1 To demonstrate proper operation of Shutdown Cooling System and the Shutdown Cooling Pumps.

2.0 PREREQUISITES

2.1 Construction activities on the systems to be tested are complete.

2.2 Plant systems required to support testing are operable and temporary systems are installed and operable.

2.3 Permanently installed instrumentation is operable and calibrated.

2.4 Test instrumentation is available and calibrated.

2.5 All lines in the Shutdown Cooling System have been filled and vented.

2.6 The LTOP valve relief capacity has been verified by bench testing.

3.0 TEST METHOD

3.1 Verify proper operation of each shutdown cooling pump with minimum flow established.

3.2 Verify pump performance including head and flow characteristics for all design flow paths which include the normal decay heat removal flow path and

1. Shutdown cooling system flow to the chemical and volume control system for purification.
2. Shutdown cooling system transfer of refueling water to the IRWST.
3. Shutdown cooling system to cool the IRWST.

3.3 Perform a full flow test of the shutdown cooling system.

3.4 Verify proper operation, stroking speed, position indication and response to interlock of control and isolation valves.

3.5 Verify the proper operation of the protective devices, controls, interlocks, indications, and alarms using actual or simulated signals.

3.6 Verify isolation valves can be opened against design differential pressure.

ATTACHMENT 7

O. Electrical Service and Lighting

The System 80+ design provides good lighting and convenient electrical service. This will facilitate maintenance and inspection activities and reduce the anticipated personnel exposure. Reliable extended service lamping in high radiation areas will be used, whenever possible, to minimize the frequency of maintenance required. The lighting fixtures are located to minimize personnel exposure during maintenance. These features are in accordance with Regulatory Guide 8.8, Position C.2.i guidance.

P. Spent Fuel Pool Decontamination

System 80+ provides the capability to use high pressure demineralized water for the decontamination the spent fuel pool. Alternative methods of decontamination, such as use of a strippable coating, may be evaluated by the operator, as practical.

12.3.1.3 <u>Source Term Control</u>

Source term control is an important aspect of the System 80+™ design. The following design features reduce the overall dose due to operation, maintenance, and inspection activities.

A. Fuel Performance

The System 80+™ design features assure low primary system sources with improved fuel clad leakage performance of less than 0.1% fuel clad failures, as well as an extended fuel cycle.

B. Corrosion Product Control

System 80+™ design includes design features that reduce corrosion product production in the primary system.

1. Primary System Materials 0.05

The System 80+™ design specifies primary system materials with low corrosion rates and very low cobalt impurities (0.020 w/o for equipment in direct contact with the primary coolant), Except where No proven alternative exists.

The presence of antimony in RCP bearings has presented a problem with hot particles in the current generation of nuclear plants. In the System 80+ design, the reactor coolant pump bearings will be designed to minimize the presence of antimony.

Steam generator tubes are fabricated to relieve stresses to reduce stress corrosion cracking. This will reduce the probability of tube plugging activities and further reduce maintenance exposures.

ATTACHMENT 8

DSER Open Item 6.3.3-1

The applicant should provide the design criteria for the SI minimum recirculation flow and provide pump operating data or test results demonstrating operability at low recirculation flow.

ABB-CE's Response

In the NRC/ABB-CE/DOE Senior Management Meeting of December 15, 1993 for the System 80+ Design Certification Program, ABB-CE presented the bases for the minimum flow and duration of the type testing that is required to be performed by the vendor for the Safety Injection Pumps. This response is provided for further clarification and to summarize the commitments made by ABB-CE at that meeting.

The Safety Injection pumps have been designed to meet all the requirements for the Safety Injection System. They are low-flow, high-head, multi-stage, low-suction-specific-speed pumps that are well suited for operation from the specified minimum flow to the design runout. This type of pump has been shown to operate successfully, especially at low flow without susceptibility to hydraulic instability and wear. The instability phenomena is a characteristic of a single-stage, high-flow, high-suction-specific-speed pump.

The issues in NRC Bulletin 88-04 and NUREG/CR-5706 have been addressed and incorporated into the design of the System 80+ SIS. These issues include arrangement items such as the elimination of the potential for "dead-heading" a pump due to pump-to-pump interactions and for "dead heading" a pump due to the location of miniflow connections relative to the pump's discharge check valve. Also, system sizing improvements have been made to allow the pumps to operate at Best Efficiency Head/flow (BEH) in the recirculation line and the minimum flowrate has been increased to approximately 10% of BEH.

The increase in the size of the miniflow line allows all inservice testing for System 80+ to be performed at BEH. This eliminates all normal operation at miniflow and minimizes wear on the pump. It also provides a better bases for assessing the performance of the SI pump as the design flow, head and vibration values provided by the vendor are used as references values for ASME OM Code compliance. Further, NUREG/CR-5706 states that BWR designs ~~have not experienced problems~~ are less likely to have problems as they do not test the safety pumps at reduced flow rates. Full flow testing has been committed to and documented in CESSAR-DC, Section 3.9.6 and Table 3.9-15 IST Plan. Therefore, System 80+ design assures maximum protection for the SI pumps.

In previous responses to DSER Open Item 6.3.3-1 and in a separate fax from M. Volodzko of ABB-CE to S. Sum of the NRC on 3/12/93, ABB-CE has provided summaries of utility and vendor testing that has demonstrated satisfactory pump operation at miniflow for periods greater than 8 hours, intermittently and continuously. This has been summarized from inservice test experience that have been gained over the life of the plants. For the System 80 design at Palo Verde, the HPSIP, which are the same pumps for System 80+ SIS, are tested quarterly at miniflow. These pumps are disassembled and inspected for wear every third outage. To date, there has been no reported wear requiring maintenance on any of the HPSI pumps.

Further, ABB-CE previously committed to provide vendor test requirements in CESSAR-DC (refer to Section 6.3.4.1.1). This section will be modified as shown in the attached markup to provide the test method and acceptance criteria for the vendor's testing at minimum flow operation. ~~Specific requirements to be provided in CESSAR-DC include a type test that verifies the SI pump's ability to operate continuously within the design limits of key parameters at minimum flow for the mission time. These key parameters~~

DSER Open Item 6.3.3-1

of interest are:

- Bearing oil equilibrium temperature: The testing will demonstrate that its temperature will not exceed the maximum safe limit for lubrication (typically, vendors have endorsed a limit of 180 °F for bearing oil temperature),
- Pump shaft seal leakage temperature: The testing will demonstrate that the temperature will not exceed the maximum safe limit for the seals (typically, vendors have endorsed a limit of 175 °F for the shaft seal cooling water),
- Pump frame vibration: Testing will demonstrate that vibrations are within the criteria established in Figure ISTB 5.2 from the ASME OM Code.

These values are based on existing centrifugal pumps designs and will demonstrate the ability of the SI pump to withstand operation at minimum flow. The duration of the test, or mission time, is either eight hours or until all of the key parameters identified above stabilize. Eight hours represents the maximum time the SI pumps are required to operate at minimum flow as discussed in CESSAR-DC Appendix 5D for a natural circulation cooldown.

6.3.4 INSPECTION AND TESTING REQUIREMENTS

During fabrication of the SIS components, tests and inspections are performed and documented in accordance with code requirements to assure high quality construction. As necessary, performance tests of components are performed in the vendor facilities. The SIS is designed and installed to permit in-service inspections and tests in accordance with the ASME Code, Section XI.

6.3.4.1 SIS Performance Tests

Prior to initial plant startup, a comprehensive series of system flow tests, as detailed in Section 14.2, will be performed to verify that the design performance of the system and individual components is attained.

Preoperational tests and analyses will be performed to confirm that the as-built SIS fulfills operability requirements and provides a level of performance that satisfies safety analyses.

6.3.4.1.1 Flow Testing

Each installed SI train will be tested to measure SI pump developed differential pressure at miniflow, measure runout flow through the DVI lines and, for SI pumps 3 and 4, measure runout flow through the hot leg injection lines. Runout flow testing will be conducted with the RCS at atmospheric pressure conditions. Test results will be used to confirm SI pump performance characteristics over the operating range of the pump and to confirm system resistance characteristics. Test conditions, including fluid temperature, suction and discharge side fluid elevations, and potential instrument uncertainties will be taken into account in performing an analysis. The analysis will use test results, with adjustments made for test conditions, to determine system performance during postulated accident conditions. The calculated system performance shall be within the limits used to perform safety analyses in Section 6.3.3 and Chapter 15.

Testing will be performed to confirm that the SI pump miniflow rate in the installed system meets or exceeds pump vendor's minimum flow requirements. The pump vendor will perform a type test to generate data that verifies the SI pump's ability to operate continuously within the design limits of key parameters at minimum flow for the mission time. These key parameters are:

- Bearing oil equilibrium temperature: The testing will demonstrate that its temperature will not exceed the maximum safe limit for lubrication (typically, vendors have endorsed a limit of 180°F for bearing oil temperature),

Replace with text on page 4 of this SAR change package

- Pump shaft seal leakage temperature: The testing will demonstrate that the temperature will not exceed the maximum safe limit for the seals (typically, vendors have endorsed a limit of 175°F for the shaft seal cooling water), and

- Pump frame vibration: Testing will demonstrate that vibrations are within the criteria established in Figure ISTB 5.2 from the ASME OM Code.

The duration of the test, or mission time, is either eight hours or until all of the key parameters stabilize, depending on whichever is longer. Eight hours represents the maximum time the SI pumps are required to operate at minimum flow as discussed in Appendix 5D for a natural circulation cooldown. After completion of the test, the SI pump will be inspected and the condition evaluated.

Testing will be performed to confirm that the SI pump return line to the IRWST allows each SI pump to be operated at a flow rate equal to or greater than design flow during inservice testing.

replace with insert, next page.

INSERT TO CESAR-DC SECTION 6.3.4.1.1 (PAGE 6.3-41)

Testing will be performed to confirm that the SI pump miniflow rate in the installed system meets or exceeds the pump vendor's minimum flow requirements. The pump vendor will perform a type test with fluid conditions representative of those during a natural circulation cooldown to generate data that verifies the SI pumps' ability to operate continuously within the design limits at minimum flow for the mission time. The pump type test will monitor the normal pump qualification test parameters and will use the following as acceptance criteria:

- Bearing oil equilibrium temperature: The testing will demonstrate that its temperature will not exceed the maximum safe limit for lubrication (typically, vendors have endorsed a limit of 180 °F for bearing oil temperature),

- Pump shaft seal leakage temperature: The testing will demonstrate that the temperature will not exceed the maximum safe limit for the seals (typically, vendors have endorsed a limit of 175 °F for the shaft seal cooling water),

- Pump bearing housing vibration: Pump bearing housing vibration will be measured in accordance with ISTB 4.6.4 from the ASME OM Code. Testing will demonstrate that vibrations are within the criteria established in Figure ISTB 5.2 from the ASME OM Code.

- Pump inspection: After completion of the test, the SI pump will be disassembled and the internals inspected with the conditions of the parts being evaluated for excessive wear as a result of degradation during the pump test.

The duration of the test, or mission time, is either eight hours or until the bearing oil temperature, the pump shaft seal leakage temperature and the pump bearing housing vibration stabilize, whichever is longer. Eight hours represents the maximum time the SI pumps are required to operate at minimum flow as discussed in Appendix 5D for a natural circulation cooldown.

ATTACHMENT 9

FAX

TO: **Nick Saltos**
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J. Longo Jr.
S. E. Ritterbusch
9424 Files
9612 files

DATE: November 29, 1993

NUMBER: OPS-93-0998

SUBJECT: Evaluation of Fire Inside Containment

In our conversation of November 22, 1993, you requested that ABB-CE provide an assessment of the potential impact of a fire inside containment on equipment needed for a safe shutdown and the attendent potential risk.

ABB-CE believes that a fire inside containment that would damage all equipment inside containment is not credible because of the limited amount of combustibles inside containment, the spatial separation of equipment, and the physical barriers witin containment. Thus, the maximum credible fiore would only affected a limited complement of equipment inside containment.

As part of the response to DSER Open Item 9.5..1.2.1-1, ABB-CE has performed an analysis of protection of redundant functions. This analysis concludes that spatial separation and location of equipment inside containment assures that a fire inside containment will not damage redundant functions. (A copy of this analysis is attached.) The primary equipment of concern inside containment includes the motor operated shutdown cooling suction isolation valves for each division, the Rapid Depressurization Valves, and instrumentation associated with the steam generators.

The SCS suction isolation valves, called RCS pressure isolation valves in the attached analysis, are located by division 180 degrees apart. The valves are located near the crane wall on either side of containment and are over 100 feet apart. They are located at elevation 101+8 which is 10 feet above the floor elevation of 91+6 feet. This separation is sufficient to ensure that at least one division of SCS is available to perform the coolown function.

The Rapid Depressurization Valves (RDVs) are located inside containment. The valves for one division are located inside the pressurizer cavity and the valves for the other division are located outside the pressurizer cavity. Thus, the RDVs for the redundant divisions are separated by a concrete wall. This ensures that one division of the Rapid Depressurization System is available to perform its function.

A fire at either steam generator could damage instrumentation associated with that steam generator. However, the other steam generator would not be affected and would be available to achieve safe shutdown. In addition, there are four channels of steam generator level and pressure instrumentation for each generator and each channel is located in a different quadrant around the steam generator.

As seen from the discussion above and that in the attachment, the maximum credible fire inside containment would affect at most the equipment associated with one division of one system used for safe shutdown (shutdown cooling system, Rapid Depressurization System or steam generator). this is consisten with the assumption in the Scoping Analysis for Fire and Flood in the System 80+ PRA that the worst possible fire could affect, at most, one division. The fire frequencies used in the scoping analysis were derived from data presented in NUREG/CR-4840, including the frequency for fires in the reactor building. A review of the information presented in table A-2 of NUREG/CR-4840 shows that this category included fires inside containment. (Note: The reported fires inside containment were local in nature.) Therefore, fires inside containment are covered in the fire frequency used in the scoping analysis

DSER Open Item 9.5.1.2.1-1

The staff does not accept the concept of radiant heat shield and 20 ft. of separation. Each such deviation inside containment must be fully justified.

Proposed Open Item 9.5.1.2.1-1 Resolution

CESSAR-DC Section 9.5.1.1.2.C will be revised to state that for inside containment or the annulus safe shutdown following a fire is ensured by separation of redundant divisions by quadrant to provide sufficient spatial separation, as proven by engineering analysis. Separation for safe shutdown cables is provided through use of mineral insulated cables which qualify as a three hour rated barrier.

CESSAR-DC Section 9.5.1.3.9 will be revised to provide an analysis of protection of redundant functions. This analysis is attached and describes arrangements for which location and spatial separation assure that fire inside containment will not damage redundant functions.

9.5.1.3 FIRE PROTECTION SAFE SHUTDOWN ANALYSIS

9.5.1.3.1 ASSUMPTIONS

- The Fire Protection Safe Shutdown Analysis includes the effects of one worst case spurious actuation.
- Fire is postulated with or without loss of offsite power (which ever is the most severe challenge to the ability to achieve safe shutdown).
- Inside containment, cables for safe shutdown valve motor operators and instruments are three hour fire rated.
- Fire is not postulated concurrent with simultaneous, coincidental failures of safety systems, other plant accidents or the most severe natural phenomena.

9.5.1.3.2 FIRE PROTECTION SAFE SHUTDOWN DESIGN BASIS GOALS

- Achieve and maintain subcritical reactivity conditions in the primary system.
- Maintain reactor coolant inventory.
- Achieve primary system temperature and pressure conditions.
- Maintain Reactor Coolant System (RCS) process variables within those predicted for loss of AC power.
- Prevent fuel clad damage, failure of the primary system pressure boundary, or rupture of the containment boundary.

9.5.1.3.3 FIRE PROTECTION SAFE SHUTDOWN DESIGN BASIS OBJECTIVES

The following Design Basis Objectives are met in order to assure the Design Basis Goals stated above are satisfied:

- Maintain RCS pressure boundary integrity (i.e., reactor coolant pump seal integrity, CVCS letdown isolation, Safety Depressurization System isolation and RCS sample line isolation).
- Assure the reactivity control function maintains the available shutdown margin at greater than 1% $\Delta k/k$ with the highest worth control element assembly (CEA) fully withdrawn.
- Assure reactor coolant make up is available to maintain

reactor coolant in the pressurizer within prescribed limits.

- Maintain RCS decay heat removal function and cool down the RCS to cold shutdown conditions.
- Provide direct reading of process variables necessary to perform and control reactivity, reactor coolant pressurizer level and decay heat removal.
- Maintain support functions (process cooling, lubrication, etc.) for equipment required for safe shutdown.

9.5.1.3.4 SYSTEMS REQUIRED FOR SAFE SHUTDOWN

- The RCS provides reactivity control by control element assembly (CEA) insertion and also removes decay heat from the core through natural circulation.
- Emergency Feedwater System (EFW) provides secondary side decay heat removal capability.
- Atmospheric Dump Valves provides secondary side pressure control capability.
- Shutdown Cooling System (SCS) provides residual heat removal function for cooldown from hot shutdown to cold shutdown conditions.
- Safety Injection System (SIS) provides makeup capability for inventory control and boron addition for reactivity control.
- Safety Depressurization System (SDS) provides primary system pressure control capability.
- Essential Chilled Water System (ECWS) provides chilled water for HVAC heat removal to all safety related room recirculation cooling units.
- Component Cooling Water System (CCWS) provides decay heat removal capability and equipment cooling for the Shutdown Cooling System, Safety Injection System, Essential Chillers, Emergency Diesel Generator Coolers, etc., as well as other non safe shutdown functions.
- Station Service Water System (SSWS) takes suction from the ultimate heat sink and provides cooling water flow to the CCWS heat exchangers for cooling and decay heat removal.
- The Control Building, Nuclear Annex, Subsphere and Diesel Generator Building Ventilation Systems provide ambient temperature control within parameters required to assure components function as intended to achieve safe shutdown conditions.

- Reactor coolant pump seal cooling is provided by either seal injection from the CVCS charging pumps or direct cooling from the CCWS.

- The Pool Cooling and Purification System provides decay heat removal from the spent fuel pool.

- The onsite Emergency Diesel Generators provide power for 1E busses for equipment power, control and instrumentation required to achieve safe shutdown conditions.

- The Combustion Turbine (AAC) provides onsite power to the permanent non-safety busses which provide power to the CVCS Charging Pumps and associated valves and controls.

Two shutdown paths are provided by the above systems. These are Division 1 and Division 2. For fires outside of the control room, one of these divisions is ensured to be available to bring the plant to safe cold shutdown.

For a Control Room fire, the Remote Shutdown Panel will be utilized as alternative shutdown capability. A fire in the Control Room is the only fire scenario which requires the Remote Shutdown Panel to be utilized. Shutdown from the Control Room can be accomplished for fires originating in all other fire areas. For the Control Room fire, both shutdown paths (i.e. Division 1 and Division 2) are available to safely shut the plant down to cold shutdown from the Remote Shutdown Panel.

Each of these systems includes adequate controls and instrumentation in the Control Room and at the Remote Shutdown Panel to assure safe shutdown can be achieved.

CESSAR-DC Section 7.4.2.5 describes the instrumentation and controls that are on the Remote Shutdown Panel that are required to bring the plant to safe cold shutdown conditions.

CESSAR-DC Section 18.3.2 describes the personnel requirements for the Control Room and Remote Shutdown Panel. Shutdown procedures following a fire will be the same as described in the plant Emergency Procedures for achieving safe cold shutdown and will not require additional personnel for the fire scenario. Safe cold shutdown can be achieved with one shutdown division within 36 hours after reactor trip.

9.5.1.3.5 SYSTEMS WHICH REQUIRE ISOLATION

- SCS pressure isolation valves until RCS is cooled and depressurized to SCS entry conditions.

- SDS to prevent uncontrolled blowdown of the RCS.

- CVCS letdown to prevent uncontrolled letdown of the RCS.

- RCS sample lines to prevent uncontrolled letdown of the RCS.
- Main Steam System to prevent uncontrolled blowdown of the steam generators.
- Atmospheric Dump Valves to prevent uncontrolled blowdown of the steam generators.
- Main Feedwater System to prevent uncontrolled blowdown of the steam generators and steam generator over fill.
- Steam Generator Blowdown System and steam generator sample lines to prevent uncontrolled blowdown of the steam generators.
- EFW to prevent steam generator over fill.

Each of these systems includes adequate controls and instrumentation in the Control Room and at the Remote Shutdown Panel.

9.5.1.3.6 ASSOCIATED CIRCUITS

The potential for electrical interaction due to fire mandates that a study be conducted to assure that redundant safe shutdown systems are not damaged by a single fire. Generic Letter 81-12 Rev. 1 defines Associated Circuits and provides guidance for documenting the Associated Circuits Study.

Outside of containment the System 80+ plant configuration provides complete separation of redundant safety related divisions by three hour fire rated barriers. Division 1 is located (plan) north of column line 17. Division 2 is located (plan) south of column line 17. An exception is the Control Room and the Remote Shutdown Panel room which are physically separated and electrically isolated and provide redundant shutdown capability. Transfer switches which transfer control from the Control Room to the Remote Shutdown Panel are located in the Control Room. Transfer switches are arranged such that when power is transferred from the Control Room to the Remote Shutdown Panel, manual operations in all four Vital Switchgear rooms are required to return control capability to the Control Room. Thus associated circuit interaction in the Control Room will not affect the ability to achieve safe shutdown from the Remote Shutdown Panel.

9.5.1.3.7 SAFE SHUTDOWN FOLLOWING FIRE OUTSIDE OF CONTAINMENT

As discussed in section 9.5.1.3.6, "Associated Circuits", redundant safe shutdown divisions are separated by column line 17. Each fire area is enclosed in three hour fire rated barriers. Three hour fire rated barrier walls are located along Column Line 17, except at elevations 115+6 and 130+6 where the Control Room is located. The exception to complete divisional separation is the Control Room and the Remote Shutdown Panel room which have redundant control function capability. They are physically separated and electrically isolated from each other. CESSAR-DC Figure 9.5.1 depicts the separation of redundant electrical divisions outside of containment.

Thus a fire in any fire area outside of containment will not affect redundant safe shutdown systems, equipment, or components.

9.5.1.3.8 SAFE SHUTDOWN FOLLOWING FIRE INSIDE CONTAINMENT

The Containment and Annulus are a single fire area. The only components inside the Containment and Annulus which are required for safe shutdown are motor operated valves and instruments associated with safe shutdown systems.

Inside the Annulus and Containment, three hour fire rated cable protective systems (i.e., mineral insulated cables) are used for cables associated with safe shutdown functions. An exception to the three hour fire resistance rating may be containment penetrations which are currently commercially available with a one hour fire resistance rating. Three hour fire rated containment penetrations will be purchased if available.

The only in situ combustible material inside containment that may be exposed to a fire is insulation of cables that are not associated with safe shutdown functions. Redundant trains of valves and instruments analyzed as an assured method of achieving safe shutdown are physically separated such that a potential fire will not affect redundant equipment as stated in section 9.5.1.3.9.

In situ combustible material inside containment is limited to those materials which are essential for unit operation (i.e., cable insulation, lubricants, etc.). The largest quantity of combustible materials is RCP motor lubrication oil. All potential leak points are enclosed in a seismically designed oil collection system which drains to a seismically designed oil collection tank. If oil were to escape from any reactor coolant pump, it would drain into the containment holdup volume. There are no safe shutdown components located in the containment holdup volume which may be damaged due to a fire at this location.

Transient combustible material will be administratively controlled to avoid unacceptable fire hazards.

9.5.1.3.9 PROTECTION OF REDUNDANT FUNCTIONS

1. <u>OBJECTIVE</u>: Maintain primary system pressure boundary integrity (i.e., reactor coolant pump seal integrity, CVCS letdown isolation , SCS isolation, SDS isolation and RCS sample line isolation).

ANALYSIS:

A. RCP seal integrity is maintained by either seal injection from the CVCS charging pumps or direct cooling from the CCWS. The CVCS is discussed in CESSAR-DC Section 9.3.4, and is shown in Figure 9.3.4-1. The CCWS is discussed in CESSAR-DC Section 9.2.2 and is shown in Figure 9.2.2-1. The RCP seals are discussed in CESSAR-DC Section 5.4.1 and are shown in Figure 5.1.2-2.

Outside containment the two divisions of CCWS are separated by a three hour fire rated barrier. In addition, the redundant CVCS charging pumps are separated by a three hour fire rated barrier. However, each division of CCWS provides seal cooling for two of the four RCPs. Should one CCWS division be lost from a fire outside of containment, RCP seal integrity of the two RCPs cooled by the CCWS division is maintained through seal injection from the CVCS charging pump in the unaffected division. The seal injection line penetrating containment is located 90 degrees apart from each containment penetration for the CCWS supply and return line to the RCPs. Each of the CCWS supply and return lines to the RCPs has two isolation valves, (For division 1, the isolation valve located inside containment has control power supplied from channel B and the isolation valve located outside of containment has control power supplied from channel A. For division 2, the isolation valve located inside containment has control power supplied from channel A and the isolation valve located outside of containment has control power supplied from channel B.). There is an isolation valve in the seal injection line located outside of containment. This valve has control power supplied from Channel C. Thus a fire outside containment cannot simultaneously isolate both seal cooling means.

Inside containment isolation and control valves on the CVCS seal injection, RCP controlled seal bleedoff and CCWS supply and return lines for the RCP seal coolers are protected such that spurious signals from a fire inside containment can not simultaneously isolate both RCP seal cooling means. Seal injection isolation valves on each side of the high pressure seal coolers are normally open with the breakers racked out. The CCW supply and return line isolation valves to each RCP are powered from the permanent non-safety electrical power busses and are normally deenergized (e.g. MCC breaker is open). The seal injection flow control and controlled seal bleedoff line valves are located near each associated RCP inside the Reactor Building crane wall. These valves are powered from the permanent non-safety electrical power busses. The containment isolation valves for the RCP seal cooler CCWS supply and return lines are powered from

Class 1E busses and are normally deenergized (e.g. MCC breaker is open). The RCP controlled seal bleedoff line containment isolation valves are also powered from Class 1E busses. These valves are normally energized (e.g. the solenoid actuators are energized to maintain the valves in the open position). However, should the RCP controlled seal bleedoff valves spuriously close, a relief valve located inside containment opens and allows continued RCP controlled seal bleedoff to the reactor drain tank. Therefore, a fire inside containment cannot simultaneously isolate both means of seal cooling.

B. The CVCS letdown line is discussed in CESSAR-DC Section 9.3.4 and is shown in Figure 9.3.4-1. The letdown line has two power operated valves in series. Each isolation valve is powered from a different division of Class 1E power and is separated and protected such that a fire inside containment can not prevent both isolation valves from closing.

C. Each division of SCS has two RCS pressure isolation valves in series. These pressure isolation valves are shown in CESSAR-DC Figure 6.3.2-1C and are discussed in Section 5.4.7. Each valve has power supplied from a different Class 1E channel and is normally deenergized (e.g. MCC breaker is open). The MCC for each valve is located outside containment in separate fire areas. In addition, the valves are "status controlled" locked closed from the Control Room via administrative procedures which require the component's discrete control device (e.g. switch or soft touch screen) to be enabled prior to valve operation. The valves are also interlocked such that they cnnnot be opened until RCS pressure reaches SCS entry conditions. Thus, neither a fire inside or outside containment is capable of spuriously opening both valves in a division.

D. Each division of SDS from the pressurizer to the In Containment Refueling Water Storage Tank (IRWST) has two power operated valves in series. Each valve has power supplied from a different Class 1E channel and is normally deenergized (e.g. MCC breaker is open). The MCC for each valve is located outside containment in separate fire areas such that a fire inside containment cannot result in spuriously opening both valves in a division.

Each division of SDS from the pressurizer to the reactor drain tank and from the top of the reactor vessel to the reactor drain tank has two power operated valves in series. Each valve has power supplied from a different Class 1E channel and is normally deenergized. The power source for each valve is located outside containment in separate fire areas such that a fire inside containment cannot result in spuriously opening both valves in a division. A fire outside containment could only affect a single valve. The SDS is discussed in CESSAR-DC Section 6.7 and is shown in Figure 5.1.2-3.

E. Primary sampling lines have a flow reducing orifice which restricts the flow to less than the normal makeup capacity. In addition, each sample line has a normally closed isolation valve inside containment and a normally closed isolation valve outside containment. Each containment isolation valve associated with a sample line penetration is powered from a different division of Class 1E power. Thus, a fire inside containment can only affect the operation of one of these valves. The sample system is discussed in CESSAR-DC Section 9.3.2, Containment Isolation is discussed in CESSAR-DC Section 6.2.4, and the containment isolation valves are shown on Figure 6.2.4-1.

2. <u>OBJECTIVE</u>: Assure the reactivity control function maintains the available shutdown margin at greater than 1% $\Delta k/k$ with the highest worth CEA fully withdrawn.

<u>ANALYSIS</u>: Reactivity control is maintained by the CEAs and by boration. The Safety Injection System (SIS) is the primary method of injecting boron into the primary system. The SIS is discussed in CESSAR-DC Section 6.3 and is shown in Figure 6.3.2-1. The majority of components in the SIS are located outside containment where each division is separated by a three hour fire rated barrier. The Safety Injection Tanks (SITs) are located inside containment. To ensure an available flowpath from each SIT, the discharge isolation valves are normally open with the breaker racked out. To prevent spurious opening of the single isolation vent valves on the SITs, the solenoid valve power supply fuses are normally removed. Thus a fire inside containment will not affect the ability to maintain reactivity control.

3. <u>OBJECTIVE:</u> Assure reactor coolant make up is available to maintain reactor coolant in the pressurizer within prescribed limits.

<u>ANALYSIS</u>: The Safety Injection System (SIS) is used for make up to the RCS. See item 2, "reactivity control", above for description and protection.

4. <u>OBJECTIVE</u>: Maintain reactor coolant decay heat removal function and cool down the RCS to cold shutdown conditions.

<u>ANALYSIS</u>:

A. Emergency Feedwater System (EFWS) provides decay heat removal from hot standby to hot shutdown conditions by supplying feedwater to each steam generator. The EFWS is discussed in CESSAR-DC Section 10.4.9 and is shown in

Figure 10.4.9-1. Each division has a motor driven and a steam driven EFW pump. Each of these pumps is sized for full capacity so that only one pump per division is necessary to achieve safe shutdown. Each pump discharge line has two motor operated valves in series. The motor driven and steam driven EFW pump of each division feed into a common supply header. All pumps and power operated valves are located outside of the containment. Thus a fire inside of containment will not affect the EFW function. Outside of containment each EFW train is separated by a three hour fire rated barrier. In order to prevent steam generator over fill, the motor operated control valve at the discharge of each pump has power supplied from a different Class 1E channel compared to the associated pump controls. The valve and pump along with associated cables are located and routed through different fire areas to prevent losing both pump and valve control due to spurious signals.

B. Steam Generator pressure control is maintained by the atmospheric dump valves which are part of the Main Steam Supply System. These valves are discussed in CESSAR-DC Section 10.3 and are shown on Figure 10.3.2-1. Each of the four main steam lines has an atmospheric dump valve (ADV) and its associated block valve located upstream of the main steam isolation valves. These valves are located outside containment in the main steam valve houses (MSVH). Thus a fire inside containment cannot affect their operation. Each MSVH, which contains two of the four ADVs, is located on opposite sides of the Reactor Building and is separated by a three hour fire rated barrier. Only one steam generator and one of the ADVs associated with that steam generator are required for decay heat removal and cooldown. Each ADV in a division has power supplied from a different Class 1E channel in its respective division. Therefore, a fire outside containment can only affect the operation of the ADVs located in the division in which the fire occurs. Thus, the ADVs in the unaffected division will be available to control pressure in the steam generator performing the cooldown function.

C. In order to prevent uncontrolled blowdown of the steam generator and steam generator overfeed, the main steam, main feedwater, and steam generator blowdown systems and the steam generator sample lines require isolation.

The Main Steam System is discussed in CESSAR-DC Section 10.3 and is shown in Figure 10.3.2-1. Each steam generator has two main steam lines. Each main steam line has a main steam isolation valve. Each main steam isolation valve has redundant solenoids powered from different Class 1E channels. In addition, these valves fail closed on loss-of-power. The main steam isolation valves are located outside of containment in their associated main steam valve house. Thus, a fire inside containment does not affect the operation of these valves. In addition, main steam can be isolated at the turbine stop valves.

The Main Feedwater System is discussed in CESSAR-DC Section 10.4.7 and is shown in Figure 10.4.7-1. Each steam generator has a economizer feedwater line and a downcomer feedwater line. Uncontrolled blowdown of a steam generator is prevented by two check valves in series on each of these lines. Steam generator over feed is prevented by closing the two feedwater isolation valves located in series on each of these lines. Each feedwater isolation valve in series has power supplied from a different Class 1E channel. In addition, these valves fail closed on loss of power. The feed water isolation valves are located outside of containment in their associated main steam valve house. Thus, a fire inside containment does not affect the operation of these valves. Main feedwater can also be isolated by stopping the main feedwater pumps.

The Steam Generator Blowdown System and the Process Sample System are discussed in CESSAR-DC Sections 10.4.8 and 9.3.2 respectively. The Steam Generator Blowdown System is shown in Figure 10.4.8-1. Each steam generator blowdown line and each steam generator sample line can be isolated by their associated containment isolation valves. Each containment penetration has a containment isolation valve located inside containment and a containment isolation valve located outside of containment. Each valve associated with a containment penetration is powered from a different division of Class 1E power. Thus, a fire inside containment can only affect the operation of one valve.

D. The Shutdown Cooling System (SCS) provides decay heat removal and cooldown after the primary system is cooled and depressurized to the point that allows opening of the RCS pressure isolation valves. The SCS cools the RCS from hot shutdown to cold shutdown conditions. The SCS is described in CESSAR-DC Section 5.4.7 and is shown in Figure 6.3.2-1. The SCS has redundant divisions. Each division takes suction from a different RCS hot leg and returns the RCS after it is cooled directly to the reactor vessel. The majority of the SCS system is located outside of containment and the redundant divisions outside of containment are separated by a three hour fire rated barrier. Only the motor operated RCS pressure isolation valves are located inside containment. There are two valves in series in each of the redundant flow paths which are located by division 180 degrees apart. These valves are located near the crane wall on either side of containment such that they are over 100 feet apart. They are located at elevation 101+8 which is 10 feet above the floor elevation of 91+6. This distance is sufficient to ensure that one division of SCS is available to perform the cooldown function.

E. The Component Cooling Water System (CCWS) and the Station Service Water System (SSWS) transfer decay heat from the SCS to the ultimate heat sink. In addition, they provide process cooling to equipment and components required for safe shutdown. These systems are discussed in CESSAR-DC Sections 9.2.2 and 9.2.1 respectively and are shown in Figures 9.2.2-1 and 9.2.1-1 respectively. Each of these systems are located outside of containment and would not be affected by a fire inside containment. Outside of containment each division is separated by a three hour fire rated barrier. An exception is the CCWS cooling to the RCP seals which has valves located inside containment. See item 1A above for analysis of this item.

5. OBJECTIVE: Provide depressurization of the RCS to allow Shutdown Cooling System to be placed in service to obtain cold shutdown conditions.

ANALYSIS: RCS depressurization is accomplished utilizing the Safety Depressurization System (SDS). The SDS is described in CESSAR-DC Section 6.7 and is shown in Figure 5.1.2-3. Depressurization is accomplished by opening the valves and controlling flow from the pressurizer to the reactor drain tank. These valves are located inside containment. Two divisions of valves located in parallel are provided. Each division of SDS from the pressurizer to the reactor drain tank has two power operated valves in series. Each valve has power supplied from a different Class 1E channel. The valves and cables are adequately separated and protected (i.e. one division is inside the pressurizer cavity and one division is outside of the pressurizer cavity) to ensure one division of SDS is available for RCS depressurization in the event of a fire inside of containment.

6. OBJECTIVE: Provide direct reading of process variables necessary to perform and control reactivity, reactor coolant pressurizer level and decay heat removal.

ANALYSIS: Instrumentation (Incore instrumentation, T-Hot, T-Cold, S\G Pressure, S\G Level, Pressurizer Pressure, Pressurizer Level, Neutron Flux): Cables for all of these instruments are three hour fire rated.

A. Neutron Flux instrumentation, T-Hot and T-Cold are located inside the primary system and are not susceptible to fire damage.

B. Pressurizer Pressure and Level instruments are located at the pressurizer. There are four channels of pressurizer pressure and level instrumentation. Each channel is located in a different quadrant around the pressurizer.

C. S\G Pressure and Level instruments: Fire at either steam generator may damage instruments associated with that steam generator. However the other steam generator would not be affected and would be available to achieve safe shutdown. In addition, there are four channels of steam generator pressure and level instrumentation and each channel is located in a different quadrant around the steam generator.

7. <u>OBJECTIVE</u>: Maintain support functions (process cooling, lubrication, etc.) for equipment required for safe shutdown.

<u>ANALYSIS</u>:

A. Component Cooling Water System (CCWS) and Station Service Water System (SSWS) are discussed in , item 4E above.

B. Lubrication: There is no equipment inside containment which requires lubrication for safe shutdown. Lubrication requirements outside of containment are divisionalized and separated by a three hour fire rated barrier.

C. Ambient cooling:

- The Essential Chilled Water System (ECWS) provides cooling water to area room coolers located outside containment. These coolers are contained in the Control Complex, Reactor Building Subsphere, and Nuclear Annex Ventilation Systems. These systems are discussed in CESSAR-DC Sections 9.2.9, 9.4.1, 9.4.5, and 9.4.9 respectively, and are shown in Figures 9.2.9-1, 9.4-2, 9.4-5, and 9.4-8 respectively. Each of these system has two divisions which are entirely located outside of containment and are separated by a three hour fire rated barrier.

- The Diesel Generator Building Ventilation System maintains the ambient conditions within the diesel generator rooms to ensure operation of the diesel generators and controls. This system is discussed in CESSAR-DC Section 9.4.4 and is shown in Figure 9.4-7. This system is located outside of containment and each division is separated by a three hour fire rated barrier.

- Equipment located inside containment is qualified for high post accident temperatures. Therefore, containment cooling is not required to ensure operation of safe shutdown equipment following a fire.

8. OBJECTIVE: Remove decay heat from the spent fuel pool.

ANALYSIS: Decay heat is removed from the spent fuel pool by the Pool Cooling and Purification System. The Pool Cooling and Purification System is discussed in CESSAR-DC Section 9.1.3 and is shown in Figure 9.1-3. All components associated with the spent fuel pool cooling function are located outside of containment and each division is separated by a three hour fire rated barrier.

9. OBJECTIVE: Provide an assured source of on-site electrical power to equipment and components required for safe shutdown.

ANALYSIS: The assured source of electrical power is either of the emergency Diesel Generators for equipment and components powered from the Class 1E busses. The electrical distribution system is discussed in CESSAR-DC Section 8.3 and is shown in Figures 8.3.1-1 and 8.3.1-2. The emergency Diesel Generators and associated Class 1E busses are located outside containment and each division is separated by a three hour fire rated barrier. The Class 1E busses are separated from the non-1E busses by two isolation breakers in series. The CVCS charging pumps are powered from the permanent non-safety busses. Emergency on-site power is supplied to these busses by the combustion turbine. The permanent non-safety busses are located in the turbine building. The Turbine Building is separated from the Nuclear Annex by a three hour fire rated barrier. The combustion turbine is located in its own structure which is separated from the Turbine Building and Nuclear Annex. Cables from the permanent non-safety busses are separated by the divisional three hour fire rated barrier after they enter the Nuclear Annex.

ATTACHMENT 10

Report No.	Title	Date Issued	CESSAR-DC Chapter
NPX-IC-DR-791-02	Human Factors Engineering Standards, Guidelines, and Bases for System 80+ LD-92-069	May 1992	18
~~LD-93-120~~ LD-94-012	System 80+ Fire Hazards Assessment R2, February 22, 1994	R0 March 13, 1992 R1 April 5, 1993	9
NPX80-IC-RR790-02, Rev. 1	Human Factors Evaluation and Allocation of System 80+ Functions LD-93-056	March 1993	18
NPX80-IC-DB-790-01	Nuplex 80+ Advanced Control Complex Design Bases LD-92-102	September 1992	18
NPX-TE-790-01	Nuplex 80+ Verification Analysis Report, LD-92-065	May 1992	18
NPX80-IC-DP790-02, Rev. 01	System 80+ Function & Task Analysis Report, LD-92-065	May 1989	18
NPX80-SQP-0101.0	Software Program Manual for NUPLEX 80+, LD-93-009	January 1993	7
NPX80-IC-QP790-2	Nuplex 80+ Software Safety Plan Description, LD-93-009	January 1993	7
NPX-IC-QG790-00	Qualification Guidelines for Instrumentation and Controls Equipment for NUPLEX 80+, LD-92-113	November 1992	7
NPX80-QPS-0401.1	Requirements for The Supply of Commercial Digital Hardware and Software Components to be used in NUPLEX 80+ Safety Systems, LD-92-114	May 1992	7

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DEPARTMENT OF ENERGY

ADVANCED LIGHT WATER REACTOR
CERTIFICATION PROGRAM

SYSTEM 80+™ DESIGN CERTIFICATION

FIRE HAZARDS ASSESSMENT

PREPARED BY
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ADVANCED NUCLEAR PROGRAMS

JANUARY 5, 1994

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FIRE HAZARDS ASSESSMENT

REVISION NO.	ISSUE DATE	DESCRIPTION OF REVISION
0	March 13, 1992	Original Issue, Volumes 1-5 Includes Fire Areas 1-175
1	April 5, 1993	Revised entire contents of Volume 1
2	August 5, 1993	Revised Fire Areas 9, 10, 11, 12, 24, 44, 45, 101 and 102. Eliminated Fire Area 49. Added Areas 48, 116 and 120. Revised pages 28, 29 and 30 of Volume 1

separation of equipment and components inside containment. In the Reactor Coolant System, motor operated valves which serve as pressure bondaries for interconnection to low pressure systems (i.e., high-low pressure interfaces) and are required to be closed during normal power operation will have one of the valve motors in each division deenergized during power operation.

7.7 REDUNDANT FIRE AREAS CONTAINING SAFE SHUTDOWN EQUIPMENT

The following identifies fire areas that contain equipment required for Safe Shutdown following a fire, and the redundant areas for the opposite division.

FIRE AREA	EQUIPMENT	REDUNDANT AREA
1	Div. 1, Channel A Vital Instrumentation	3
2	Div. 1, Channel C Vital Instrumentation	4
3	Div. 2, Channel B Vital Instrumentation	1
4	Div. 2, Channel D Vital Instrumentation	2
9	Div. 1A, CCW Pump	12
10	Div. 1B, CCW Pump	11
11	Div. 2A, CCW Pump	10
12	Div. 2B, CCW Pump	9
15	Div. 1, Control Room HVAC	16
16	Div. 2, Control Room HVAC	15
21	Div. 1, Channel A Cable	22
22	Div. 2, Channel B Cable	21
24	Div. 2, CCW Piping	48
32	Div. 2, Cable	33
33	Div. 1, Cable	32
34	Div. 1, Motor Driven Emergency	35

FIRE AREA	EQUIPMENT	REDUNDANT AREA
	Feedwater Pump	
35	Div. 2, Motor Driven Emergency Feedwater Pump	34
36	Div. 1, Turbine Driven Emergency Feedwater Pump	37
37	Div. 2, Turbine Driven Emergency Feedwater Pump	36
38	Div. 1A, SI Pump	39
39	Div. 2A, SI Pump	38
40	Div. 2B, SI Pump and Div. 2, Shutdown Cooling Pump	41
41	Div. 1A, SI Pump and Div. 1, Shutdown Cooling Pump	40
42	Div. 2, Emergency Diesel Generator	43
43	Div. 1, Emergency Diesel Generator	42
44	Div. 1, Charging Pump	45
45	Div. 2, Charging Pump	44
48	Div. 2, CCW Piping	24
53	Div. 2, Cable	54
54	Div. 1, Cable	53
55	Div. 2, Cable	56
56	Div. 1, Cable	55
57	Div. 1, Essential Chilled Water	58
58	Div. 2, Essential Chilled Water	57
63	Div. 1, Channel C Cable	64
64	Div. 2, Channel D Cable	63
65	Div. 1, Channel A Equipment	66
66	Div. 2, Channel B Equipment	65
70	Div. 1, Channel C Switchgear	71
71	Div. 2, Channel D Switchgear	70
73	Div. 1, Channel C Equipment	74
74	Div. 2, Channel D Equipment	73
77	Div. 2, Fuel Pool Cooling Equipment	80

FIRE AREA	EQUIPMENT	REDUNDANT AREA
78	Div. 2, Valve Gallery	79
79	Div. 1, Valve Gallery	78
80	Div. 1, Fuel Pool Cooling Equipment	77
82	Div. 1, Emergency Feedwater Tank	83
83	Div. 2, Emergency Feedwater Tank	82
84	Div. 1, Main Steam Valve House	85
85	Div. 2, Main Steam Valve House	84
95	Div. 1, Channel A Penetration Room	96
96	Div. 2, Channel B Penetration Room	95
97	Div. 1, Channel C Penetration Room	98
98	Div. 2, Channel D Penetration Room	97
116	Div. 1, Channel C Multiplexer Room	120
120	Div. 2, Channel D Multiplexer Room	116
166	Div. 1, CCW Surge Tank	167
167	Div. 2, CCW Surge Tank	166

FIRE AREA 24

I. GENERAL

A. DESCRIPTION

1. Pipe Chase

Located on EL. 50+0 through 170+0 at column N-O and column 11-12. (See CESSAR-DC Figure 9.5.1-2 through 9.5.1-9)

2. Construction Features

a. Walls

Walls are constructed of reinforced concrete.

b. Ceiling/Floor

Ceiling and floor are constructed of reinforced concrete.

c. Interior Finish

There are no combustible interior finish materials in this area.

3. Occupancy

a. This area contains piping.

(1) Safety Division/Channel

Equipment in the area is associated with safety Division II.

(2) Major Equipment

(a) Piping

(3) Function for Safe Shutdown

This area will contain Component Cooling Water and other safety related piping.

(4) Importance to plant operation

This area contains normal operating system piping.

(5) Location of Redundant Systems/Equipment

Equipment which provides redundant safe shutdown functions is located in Fire Area 48 (Division I).

(6) High Energy Equipment/Voltages

None

(7) Heat Sensitive Equipment

None

(8) HVAC

(8) HVAC

None

(9) Acceptable Level of Risk

Category 2

B. OPERATOR ACTIONS

1. Normal Procedures

TBD

2. Non-Fire Emergency Procedures

TBD

C. <u>MAINTENANCE ACTIVITIES</u>

1. Equipment Disassembly & Laydown

TBD

2. Use of Solvents

TBD

D. <u>OTHER ACTIVITIES</u>

1. Health Physics

TBD

2. Chemistry

TBD

3. Testing

TBD

E. <u>RADIOLOGICAL/TOXIC MATERIAL</u>

Radiological or toxic material are not present in the area.

F. <u>POTENTIAL IGNITION SOURCE</u>

None

G. <u>CURBS, DRAINS, EQUIPMENT PEDESTALS</u>

None

H. <u>SUMMARY OF COMBUSTIBLE MATERIALS</u>

None

II. <u>FIRE PROTECTION FEATURES</u>

A. FIXED AUTOMATIC SUPPRESSION SYSTEMS

None

a. Location of Device

TBD (In accordance with NFPA 101)

b. Annunciation Location

TBD

6. Fire Barrier/Insulating Material

a. Walls/Floors/Ceiling

(1) Location

As shown on CESSAR-DC Figure 9.5.1-6.

(2) Rating

Three hour fire rating for walls, floor and ceiling.

(3) Method of Qualification

Laboratory test or engineering analysis

b. Doors

(1) Location

As shown on CESSAR-DC Figure 9.5.1-6

(2) Rating

Three hour fire rating

(3) Method of Qualification

Laboratory test or engineering analysis

c. Dampers

(1) Location

TBD

(2) Rating

TBD

(3) Method of Qualification

Laboratory test or engineering analysis

d. Penetration Seals

(1) Location

TBD

(2) Rating

Wall, floor and ceiling penetrations are sealed to maintain a three hour rating.

(3) Method of Qualification

b. Cloths
c. Janitorial Supplies
d. Documents

II. FIRE PROTECTION FEATURES

A. FIXED AUTOMATIC SUPPRESSION SYSTEMS

None

B. MANUAL FIRE SUPPRESSION SYSTEMS

1. Hose Stations

a. Location

TBD (In accordance with NFPA 14)

b. Length

Nominal 75 feet or 100 feet, TBD

c. Nozzle

Nonadjustable spray nozzle with fixed angle of spray for use on electrical fire to avoid the possibility of applying a straight stream on the electrical equipment.

2. Fire Extinguisher

a. Location

TBD (In accordance with NFPA 10)

b. Type

TBD

3. Fire Suppression System Valves

a. Location

TBD

b. Control Function

TBD

c. Supervision

TBD

4. Detection

a. Type

The equipment used is a UL listed or FM approved smoke detection type.

b. Selection for Hazard

Ionization detector

5. Alarms/Pull Station

(8) HVAC

TBD

(9) Acceptable Level of Risk

Category 2

B. OPERATOR ACTIONS

1. Normal Procedures

TBD

2. Non-Fire Emergency Procedures

TBD

C. MAINTENANCE ACTIVITIES

1. Equipment Disassembly & Laydown

TBD

2. Use of Solvents

TBD

D. OTHER ACTIVITIES

1. Health Physics

TBD

2. Chemistry

TBD

3. Testing

TBD

E. RADIOLOGICAL/TOXIC MATERIAL

TBD

F. POTENTIAL IGNITION SOURCE

High voltage electrical equipment is a potential ignition source.

G. CURBS, DRAINS, EQUIPMENT PEDESTALS

Electrical equipment is mounted on 6-inch pedestals to prevent water infiltration in the event of uncontrolled water release into the area.

H. SUMMARY OF COMBUSTIBLE MATERIALS

1. Insitu Combustible Materials

a. Cable Insulation

2. Transient Combustible Materials

a. Cleaning Solvents

FIRE AREA 116

I. GENERAL

A. DESCRIPTION

1. Division I Channel C Multiplexer

   Located on EL. 115 + 6 at columns Q-O and rows 19-21 (See CESSAR-DC Figure 9.5.1-6).

2. Construction Features

   a. Walls

      Walls are constructed of reinforced concrete.

   b. Ceiling/Floor

      Ceiling and floor are constructed of reinforced concrete.

   c. Interior Finish

      There are no combustible interior finish materials in this area.

3. Occupancy

   a. The area contains electrical equipment.

      (1) Safety Division/Channel

          Equipment in the area is associated with safety Division I Channel C.

      (2) Major Equipment

          (a) Multiplexer
          (b) MCC

      (3) Function for Safe Shutdown

          TBD

      (4) Importance to plant operation

          TBD

      (5) Location of Redundant Systems/Equipment

          Equipment which provides redundant safe shutdown functions is located in Fire Area 120 (Division II Channel D).

      (6) High Energy Equipment/Voltages

          (a) MCC 480 VAC

      (7) Heat Sensitive Equipment

          Multiplexer
          MCC

(1) Primary

Smoke detection

(2) Secondary

Fire extinguisher and hose lines

b. Passive Systems

Fire barriers

c. Defense-in-Depth

The defense-in-depth philosophy involves a combination of fire barriers and manual suppression systems (i.e. hose lines and extinguishers).

14. Consequences of Fire

a. With Detection & Alarm Systems Functioning

The smoke detection system alarms to indicate particles of combustion present in the area. Combustibles are such that a slow growth fire would be expected, so that the possibility of extinguishing a small fire with an extinguisher is good. The fire brigade responds to insure no smoldering material is left or to use hose lines to extinguish a fire that becomes too intense.

b. Without Detection & Alarm Systems Functioning

A fire in the area could possibly cause loss of equipment if the smoke detection system did not function. The redundant equipment in Fire Area 101 (Division I, Channel C) provides redundant safe shutdown functions. The Fire Areas 101 and 102 are separated by three hour fire rated barriers with no communicating openings.

15. Compliance with Design Basis

The fire protection features for Fire Area 102 achieve the Design Basis Goals outlined CESSAR-DC Section 9.5.1 "Fire Protection Systems."

(3) Method of Qualification

Laboratory test or engineering analysis

d. Penetration Seals

(1) Location

TBD

(2) Rating

Wall, floor and ceiling penetrations are sealed to maintain a three hour fire rating.

(3) Method of Qualification

Laboratory test or engineering analysis

7. Method of Communication to Control Room/Public Address

TBD

8. Personnel Egress/Fire Brigade Access

a. Primary

Stairwell at column P and column 12.

b. Secondary

Stairwell at column C and column 10.

9. Potential Effects of Fixed Automatic Suppression System

Not Applicable

10. Potential Effects of Fire Brigade Activities

a. Water Spray

TBD

b. Particles of Combustion

TBD

11. Radiological Consequences of Fire

TBD

12. Smoke Control Methods

A smoke purge system is provided to remove products of combustion in the event of a fire in the area. During smoke purge, the smoke purge fan is started and the area is supplied with make-up air to provide a once through ventilation system. The smoke purge mode of operation is manually activated by the control room operator.

13. Summary of Fire Protection Features

a. Active Systems

c. Supervision

TBD

4. Detection

a. Type

The equipment used is a UL listed or FM approved smoke detection type.

b. Selection for Hazard

Ionization detector

5. Alarms/Pull Station

a. Location of Device

TBD (In accordance with NFPA 101)

b. Annunciation Location

TBD

6. Fire Barrier/Insulating Material

a. Walls/Floors/Ceiling

(1) Location

As shown on CESSAR-DC Figure 9.5.1-5.

(2) Rating

Three hour fire rating for walls, floor and ceiling.

(3) Method of Qualification

Laboratory test or engineering analysis

b. Doors

(1) Location

As shown on CESSAR-DC Figure 9.5.1-5.

(2) Rating

Three hour fire rating

(3) Method of Qualification

Laboratory test or engineering analysis

c. Dampers

(1) Location

TBD

(2) Rating

TBD

G. CURBS, DRAINS, EQUIPMENT PEDESTALS

Electrical equipment is mounted on 6-inch pedestals to prevent water infiltration in the event of uncontrolled water release into the area.

H. SUMMARY OF COMBUSTIBLE MATERIALS

1. Insitu Combustible Materials

   a. Cable Insulation (Approximately 1000 feet)
   b. Combustible Duct/Pipe Insulation (Limited)
   c. Bearing Lubricant (Recirculation Cooling Unit, Minimal)

2. Transient Combustible Materials

   a. Cleaning Solvents
   b. Cloths
   c. Janitorial Supplies
   d. Documents
   e. Scaffolding Boards

II. FIRE PROTECTION FEATURES

A. FIXED AUTOMATIC SUPPRESSION SYSTEMS

None

B. MANUAL FIRE SUPPRESSION SYSTEMS

1. Hose Stations

   a. Location

      TBD (In accordance with NFPA 14)

   b. Length

      Nominal 75 feet or 100 feet

   c. Nozzle

      Nonadjustable spray nozzle with fixed angle of spray for use on electrical fire to avoid the possibility of applying a straight stream on the electrical equipment.

2. Fire Extinguisher

   a. Location

      TBD (In accordance with NFPA 10)

   b. Type

      Carbon Dioxide

3. Fire Suppression System Valves

   a. Location

      TBD

   b. Control Function

      TBD

(b) Recirculation Cooling Units 480 VAC

(7) Heat Sensitive Equipment

Electronic components are qualified to withstand a minimum ambient temperature of 55 °F continuous or 122 °F for 60 minutes without failure.

(8) HVAC

During normal plant operations, HVAC is supplied by one of two redundant air-handling units serving this area. Instrumentation and controls provide manual operation of the system from local and/or remote locations. Indication of fan operating status, damper positions, and high room temperature alarms are provided in the Control Room.

(9) Acceptable Level of Risk

Category 2

B. OPERATOR ACTIONS

1. Normal Procedures

TBD

2. Non-Fire Emergency Procedures

TBD

C. <u>MAINTENANCE ACTIVITIES</u>

1. Equipment Disassembly & Laydown

TBD

2. Use of Solvents

TBD

D. <u>OTHER ACTIVITIES</u>

1. Health Physics

TBD

2. Chemistry

TBD

3. Testing

Battery testing

E. <u>RADIOLOGICAL/TOXIC MATERIAL</u>

Battery faults, inverters, etc. are possible sources of toxic material in the area.

F. <u>POTENTIAL IGNITION SOURCE</u>

Electrical equipment is a potential ignition source.

FIRE AREA 102

I. GENERAL

A. DESCRIPTION

1. Division II, Channel D Non-Essential Equipment Room, includes areas on EL. 50+0, EL. 70+0 and EL. 81+0 between columns O-P and rows 13-14, on EL. 91+9 between columns O-Q and rows 13-15, on EL. 115+6 between columns O-Q and rows 12-14 (See CESSAR-DC Figures 9.5.1-2 through 6).

2. Construction Features

a. Walls

Walls are constructed of reinforced concrete.

b. Ceiling/Floor

Ceiling and floor are constructed of reinforced concrete.

c. Interior Finish

There are no combustible interior finish materials in this area.

3. Occupancy

a. The area contains non-essential electrical equipment.

(1) Safety Division/Channel

Equipment in the area is associated with safety Division II, Channel D, but is not safety related.

(2) Major Equipment

(a) Multiplex Cabinets
(b) Inverter
(c) Battery Charger
(d) Batteries
(e) Power Panel Boards and Distribution Center
(f) Recirculation Cooling Units
(g) MCC

(3) Function for Safe Shutdown

None

(4) Importance to plant operation

Equipment in this area provides power, control, and instrumentation to various non-essential systems.

(5) Location of Redundant Systems/Equipment

Equipment which provides redundant functions is located in Fire Area 101 (Division I, Channel C).

(6) High Energy Equipment/Voltages

(a) MCC 480 VAC

Smoke detection

(2) Secondary

Fire extinguisher and hose lines

b. Passive Systems

Fire barriers

c. Defense-in-Depth

The defense-in-depth philosophy involves a combination of fire barriers and manual suppression systems (i.e. hose lines and extinguishers).

14. Consequences of Fire

a. With Detection & Alarm Systems Functioning

The smoke detection system alarms to indicate particles of combustion present in the area. Combustibles are such that a slow growth fire would be expected, so that the possibility of extinguishing a small fire with an extinguisher is good. The fire brigade responds to insure no smoldering material is left or to use hose lines to extinguish a fire that becomes too intense.

b. Without Detection & Alarm Systems Functioning

A fire in the area could possibly cause loss of equipment if the smoke detection system did not function. The redundant equipment in Fire Area 102 (Division II, Channel D) provides redundant safe shutdown functions. The Fire Areas 101 and 102 are separated by three hour fire rated barriers with no communicating openings.

15. Compliance with Design Basis

The fire protection features for Fire Area 101 achieve the Design Basis Goals outlined CESSAR-DC Section 9.5.1 "Fire Protection Systems."

Laboratory test or engineering analysis

d. Penetration Seals

(1) Location

TBD

(2) Rating

Wall, floor and ceiling penetrations are sealed to maintain a three hour fire rating.

(3) Method of Qualification

Laboratory test or engineering analysis

7. Method of Communication to Control Room/Public Address

TBD

8. Personnel Egress/Fire Brigade Access

a. Primary

Stairwell at column P and column 22.

b. Secondary

Stairwell at column C and column 24.

9. Potential Effects of Fixed Automatic Suppression System

Not Applicable

10. Potential Effects of Fire Brigade Activities

a. Water Spray

TBD

b. Particles of Combustion

TBD

11. Radiological Consequences of Fire

TBD

12. Smoke Control Methods

A smoke purge system is provided to remove products of combustion in the event of a fire in the area. During smoke purge, the smoke purge fan is started and the area is supplied with make-up air to provide a once through ventilation system. The smoke purge mode of operation is manually activated by the control room operator.

13. Summary of Fire Protection Features

a. Active Systems

(1) Primary

TBD

4. Detection

a. Type

The equipment used is a UL listed or FM approved smoke detection type.

b. Selection for Hazard

Ionization detector

5. Alarms/Pull Station

a. Location of Device

TBD (In accordance with NFPA 101)

b. Annunciation Location

TBD

6. Fire Barrier/Insulating Material

a. Walls/Floors/Ceiling

(1) Location

As shown on CESSAR-DC Figure 9.5.1-5.

(2) Rating

Three hour fire rating for walls, floor and ceiling.

(3) Method of Qualification

Laboratory test or engineering analysis

b. Doors

(1) Location

As shown on CESSAR-DC Figure 9.5.1-5.

(2) Rating

Three hour fire rating

(3) Method of Qualification

Laboratory test or engineering analysis

c. Dampers

(1) Location

TBD

(2) Rating

TBD

(3) Method of Qualification

Electrical equipment is mounted on 6-inch pedestals to prevent water infiltration in the event of uncontrolled water release into the area.

H. SUMMARY OF COMBUSTIBLE MATERIALS

1. Insitu Combustible Materials

   a. Cable Insulation (Approximately 1000 feet)
   b. Combustible Duct/Pipe Insulation (Limited)
   c. Bearing Lubricant (Recirculation Cooling Unit, Minimal)

2. Transient Combustible Materials

   a. Cleaning Solvents
   b. Cloths
   c. Janitorial Supplies
   d. Documents
   e. Scaffolding Boards

II. FIRE PROTECTION FEATURES

A. FIXED AUTOMATIC SUPPRESSION SYSTEMS

None

B. MANUAL FIRE SUPPRESSION SYSTEMS

1. Hose Stations

   a. Location

      TBD (In accordance with NFPA 14)

   b. Length

      Nominal 75 feet or 100 feet

   c. Nozzle

      Non-adjustable spray nozzle with fixed angle of spray for use on electrical fire to avoid the possibility of applying a straight stream on the electrical equipment.

2. Fire Extinguisher

   a. Location

      TBD (In accordance with NFPA 10)

   b. Type

      Carbon Dioxide

3. Fire Suppression System Valves

   a. Location

      TBD

   b. Control Function

      TBD

   c. Supervision

(7) Heat Sensitive Equipment

Electronic components are qualified to withstand a minimum ambient temperature of 55 °F continuous or 122 °F for 60 minutes without failure.

(8) HVAC

During normal plant operations, HVAC is supplied by one of two redundant air-handling units serving this area. Instrumentation and controls provide manual operation of the system from local and/or remote locations. Indication of fan operating status, damper positions, and high room temperature alarms are provided in the Control Room.

(9) Acceptable Level of Risk

Category 2

B. OPERATOR ACTIONS

1. Normal Procedures

TBD

2. Non-Fire Emergency Procedures

TBD

C. MAINTENANCE ACTIVITIES

1. Equipment Disassembly & Laydown

TBD

2. Use of Solvents

TBD

D. OTHER ACTIVITIES

1. Health Physics

TBD

2. Chemistry

TBD

3. Testing

Battery testing

E. RADIOLOGICAL/TOXIC MATERIAL

Battery faults, inverters, etc. are possible sources of toxic material in the area.

F. POTENTIAL IGNITION SOURCE

Electrical equipment is a potential ignition source.

G. CURBS, DRAINS, EQUIPMENT PEDESTALS

FIRE AREA 101

I. GENERAL

A. DESCRIPTION

1. Division I, Channel C Non-Essential Equipment Room, includes areas on EL. 50+0, and EL. 70+0 between columns O-P and rows 20-21; on EL. 91+9 and EL. 115+6 between columns O-Q and rows 20-21a (See CESSAR-DC Figures 9.5.1-2 through 6).

2. Construction Features

a. Walls

Walls are constructed of reinforced concrete.

b. Ceiling/Floor

Ceiling and floor are constructed of reinforced concrete.

c. Interior Finish

There are no combustible interior finish materials in this area.

3. Occupancy

a. The area contains non-essential electrical equipment.

(1) Safety Division/Channel

Equipment in the area is associated with safety Division I, Channel C, but is not safety related.

(2) Major Equipment

(a) Multiplex Cabinets
(b) Inverter
(c) Battery Charger
(d) Batteries
(e) Power Panel Boards and Distribution Center
(f) Recirculation Cooling Units
(g) MCC

(3) Function for Safe Shutdown

None

(4) Importance to plant operation

Equipment in this area provides power, control, and instrumentation to various non-essential systems.

(5) Location of Redundant Systems/Equipment

Equipment which provides redundant functions is located in Fire Area 102 (Division II, Channel D).

(6) High Energy Equipment/Voltages

(a) MCC 480 VAC
(b) Recirculation Cooling Units 480 VAC

THIS NUMBER IS RESERVED
FOR FUTURE ASSIGNMENT

11. Radiological Consequences of Fire

TBD

12. Smoke Control Methods

None

13. Summary of Fire Protection Features

a. Active Systems

Fire Extinguishers and Hose Lines

b. Passive Systems

Fire Barrier

c. Defense-in-Depth

The defense-in-depth philosophy involves a combination of fire barriers and manual suppression systems (i.e. hose lines and extinguishers).

14. Consequences of Fire

There are no combustibles in this area to support fire ignition or propagation.

15. Compliance with Design Basis

The fire protection features for Fire Area 24 achieve the Design Basis Goals outlined CESSAR-DC Section 9.5.1 "Fire Protection Systems."

(3) Method of Qualification

Laboratory test or engineering analysis

b. Doors

(1) Location

TBD

(2) Rating

Three hour rating

(3) Method of Qualification

Laboratory test or engineering analysis

c. Dampers

None

d. Penetration Seals

(1) Location

TBD

(2) Rating

Three hour rating

(3) Method of Qualification

Laboratory test or engineering analysis

7. Method of Communication to Control Room/Public Address

TBD

8. Personnel Egress/Fire Brigade Access

a. Primary

TBD

b. Secondary

TBD

9. Potential Effects of Automatic Suppression System

Not Applicable

10. Potential Effects of Fire Brigade Activities

a. Water Spray

TBD

b. Particles of Combustion

TBD

1. Hose Stations

   a. Location

      TBD (In accordance with NFPA 14)

   b. Length

      Nominal 75 feet or 100 feet, TBD

   c. Nozzle

      Adjustable spray nozzle

2. Fire Extinguisher

   a. Location

      TBD (In accordance with NFPA 10)

   b. Type

      Carbon Dioxide

3. Fire Suppression System Valves

   a. Location

      TBD

   b. Control Function

      TBD

   c. Supervision

      TBD

4. Detection

   None

5. Alarms/Pull Station

   a. Location of Device

      TBD (In accordance with NFPA 101)

   b. Annunciation Location

      TBD

6. Fire Barrier/Insulating Material

   a. Walls/Floors/Ceiling

      (1) Location

          As shown on CESSAR-DC Figure 9.5.1-2 through 9.5.1-9

      (2) Rating

          Three hour rating

None

(9) Acceptable Level of Risk

Category 2

B. OPERATOR ACTIONS

1. Normal Procedures

TBD

2. Non-Fire Emergency Procedures

TBD

C. MAINTENANCE ACTIVITIES

1. Equipment Disassembly & Laydown

TBD

2. Use of Solvents

TBD

D. OTHER ACTIVITIES

1. Health Physics

TBD

2. Chemistry

TBD

3. Testing

TBD

E. RADIOLOGICAL/TOXIC MATERIAL

Radiological or toxic material are not present in the area.

F. POTENTIAL IGNITION SOURCE

None

G. CURBS, DRAINS, EQUIPMENT PEDESTALS

None

H. SUMMARY OF COMBUSTIBLE MATERIALS

None

II. FIRE PROTECTION FEATURES

A. FIXED AUTOMATIC SUPPRESSION SYSTEMS

None

B. MANUAL FIRE SUPPRESSION SYSTEMS

FIRE AREA 48

I. GENERAL

A. DESCRIPTION

1. Pipe Chase

   Located on EL. 50+0 through 170+0 at column N-O and column 22-23. (See CESSAR-DC Figure 9.5.1-2 through 9.5.1-9)

2. Construction Features

   a. Walls

      Walls are constructed of reinforced concrete.

   b. Ceiling/Floor

      Ceiling and floor are constructed of reinforced concrete.

   c. Interior Finish

      There are no combustible interior finish materials in this area.

3. Occupancy

   a. This area contains piping.

      (1) Safety Division/Channel

      Equipment in the area is associated with safety Division II.

      (2) Major Equipment

      (a) Piping

      (3) Function for Safe Shutdown

      This area will contain Component Cooling Water and other safety related piping.

      (4) Importance to plant operation

      This area contains normal operating system piping.

      (5) Location of Redundant Systems/Equipment

      Equipment which provides redundant safe shutdown functions is located in Fire Area 24 (Division II).

      (6) High Energy Equipment/Voltages

      None

      (7) Heat Sensitive Equipment

      None

      (8) HVAC

b. Particles of Combustion

TBD

11. Radiological Consequences of Fire

TBD

12. Smoke Control Methods

None

13. Summary of Fire Protection Features

a. Active Systems

Fire Extinguishers and Hose Lines

b. Passive Systems

Fire Barrier

c. Defense-in-Depth

The defense-in-depth philosophy involves a combination of fire barriers and manual suppression systems (i.e. hose lines and extinguishers).

14. Consequences of Fire

There are no combustibles in this area to support fire ignition or propagation.

15. Compliance with Design Basis

The fire protection features for Fire Area 24 achieve the Design Basis Goals outlined CESSAR-DC Section 9.5.1 "Fire Protection Systems."

(2) Rating

Three hour rating

(3) Method of Qualification

Laboratory test or engineering analysis

b. Doors

(1) Location

TBD

(2) Rating

Three hour rating

(3) Method of Qualification

Laboratory test or engineering analysis

c. Dampers

None

d. Penetration Seals

(1) Location

TBD

(2) Rating

Three hour rating

(3) Method of Qualification

Laboratory test or engineering analysis

7. Method of Communication to Control Room/Public Address

TBD

8. Personnel Egress/Fire Brigade Access

a. Primary

TBD

b. Secondary

TBD

9. Potential Effects of Automatic Suppression System

Not Applicable

10. Potential Effects of Fire Brigade Activities

a. Water Spray

TBD

B. MANUAL FIRE SUPPRESSION SYSTEMS

1. Hose Stations

    a. Location

        TBD (In accordance with NFPA 14)

    b. Length

        Nominal 75 feet or 100 feet, TBD

    c. Nozzle

        Adjustable spray nozzle

2. Fire Extinguisher

    a. Location

        TBD (In accordance with NFPA 10)

    b. Type

        Carbon Dioxide

3. Fire Suppression System Valves

    a. Location

        TBD

    b. Control Function

        TBD

    c. Supervision

        TBD

4. Detection

    None

5. Alarms/Pull Station

    a. Location of Device

        TBD (In accordance with NFPA 101)

    b. Annunciation Location

        TBD

6. Fire Barrier/Insulating Material

    a. Walls/Floors/Ceiling

        (1) Location

            As shown on CESSAR-DC Figure 9.5.1-2 through 9.5.1-9

Laboratory test or engineering analysis

7. Method of Communication to Control Room/Public Address

   TBD

8. Personnel Egress/Fire Brigade Access

   a. Primary

      TBD

   b. Secondary

      TBD

   c. Emergency Lighting

      Emergency lighting will be provided in this area per NFPA 101.

9. Potential Effects of Fixed Automatic Suppression System

   Not Applicable

10. Potential Effects of Fire Brigade Activities

    a. Water Spray

       TBD

    b. Particles of Combustion

       TBD

11. Radiological Consequences of Fire

    Not applicable

12. Smoke Control Methods

    A smoke purge system is provided to remove products of combustion in the event of a fire in the area. During smoke purge, the smoke purge fan is started and the area is supplied with make-up air to provide a once through ventilation system. The smoke purge mode of operation is manually activated by the control room operator.

13. Summary of Fire Protection Features

    a. Active Systems

       (1) Primary

           Smoke detection

       (2) Secondary

           Fire extinguisher and fire hose

    b. Passive Systems

       Fire barriers

c. Defense-in-Depth

The defense-in-depth philosophy involves a combination of fire barriers and manual suppression systems (i.e. hose lines and extinguishers).

14. Consequences of Fire

a. With Detection & Alarm Systems Functioning

The smoke detection system alarms to indicate particles of combustion present in the area. Combustibles are such that a slow growth fire is expected so that the possibility of extinguishing a small fire with an extinguisher is good. The fire brigade responds to insure no smoldering material is left or to use the hose line to extinguish a fire that becomes too intense.

b. Without Detection & Alarm Systems Functioning

A fire in the area could possibly cause loss of equipment if the smoke detection system did not function. The redundant equipment is located in Fire Area 120 (Division II Channel D). The Fire Areas 116 and 120 are separated by multiple layers of three hour fire rated barriers.

15. Compliance with Design Basis

The fire protection features for Fire Area 116 achieve the Design Basis Goals outlined CESSAR-DC Section 9.5.1 "Fire Protection Systems."

FIRE AREA 120

I. GENERAL

A. DESCRIPTION

1. Division II Channel D Multiplexer

Located on EL. 115 + 6 between columns Q-O and rows 13a-15 (See CESSAR-DC Figure 9.5.1-6).

2. Construction Features

a. Walls

Walls are constructed of reinforced concrete.

b. Ceiling/Floor

Ceiling and floor are constructed of reinforced concrete.

c. Interior Finish

There are no combustible interior finish materials in this area.

3. Occupancy

a. The area contains electrical equipment.

(1) Safety Division/Channel

Equipment in the area is associated with safety Division I Channel C.

(2) Major Equipment

(a) Multiplex Cabinets
(b) MCC

(3) Function for Safe Shutdown

TBD

(4) Importance to plant operation

TBD

(5) Location of Redundant Systems/Equipment

Equipment which provides redundant safe shutdown functions is located in Fire Area 116 (Division I Channel C).

(6) High Energy Equipment/Voltages

(a) MCC 480 VAC

(7) Heat Sensitive Equipment

Multiplexer
MCC

(8) HVAC

TBD

(9) Acceptable Level of Risk

Category 2

B. OPERATOR ACTIONS

1. Normal Procedures

TBD

2. Non-Fire Emergency Procedures

TBD

C. <u>MAINTENANCE ACTIVITIES</u>

1. Equipment Disassembly & Laydown

TBD

2. Use of Solvents

TBD

D. <u>OTHER ACTIVITIES</u>

1. Health Physics

TBD

2. Chemistry

TBD

3. Testing

TBD

E. <u>RADIOLOGICAL/TOXIC MATERIAL</u>

TBD

F. <u>POTENTIAL IGNITION SOURCE</u>

High voltage electrical equipment is a potential ignition source.

G. <u>CURBS, DRAINS, EQUIPMENT PEDESTALS</u>

Electrical equipment is mounted on 6-inch pedestals to prevent water infiltration in the event of uncontrolled water release into the area.

H. <u>SUMMARY OF COMBUSTIBLE MATERIALS</u>

1. Insitu Combustible Materials

a. Cable Insulation

2. Transient Combustible Materials

a. Cleaning Solvents

b. Cloths
c. Janitorial Supplies
d. Documents

II. FIRE PROTECTION FEATURES

A. FIXED AUTOMATIC SUPPRESSION SYSTEMS

None

B. MANUAL FIRE SUPPRESSION SYSTEMS

1. Hose Stations

   a. Location

      TBD (In accordance with NFPA 14)

   b. Length

      Nominal 75 feet or 100 feet, TBD

   c. Nozzle

      Nonadjustable spray nozzle with fixed angle of spray for use on electrical fire to avoid the possibility of applying a straight stream on the electrical equipment.

2. Fire Extinguisher

   a. Location

      TBD (In accordance with NFPA 10)

   b. Type

      TBD

3. Fire Suppression System Valves

   a. Location

      TBD

   b. Control Function

      TBD

   c. Supervision

      TBD

4. Detection

   a. Type

      The equipment used is a UL listed or FM approved smoke detection type.

   b. Selection for Hazard

      Ionization detector

5. Alarms/Pull Station

a. Location of Device

TBD (In accordance with NFPA 101)

b. Annunciation Location

TBD

6. Fire Barrier/Insulating Material

a. Walls/Floors/Ceiling

(1) Location

As shown on CESSAR-DC Figure 9.5.1-6.

(2) Rating

Three hour fire rating for walls, floor and ceiling.

(3) Method of Qualification

Laboratory test or engineering analysis

b. Doors

(1) Location

As shown on CESSAR-DC Figure 9.5.1-6

(2) Rating

Three hour fire rating

(3) Method of Qualification

Laboratory test or engineering analysis

c. Dampers

(1) Location

TBD

(2) Rating

TBD

(3) Method of Qualification

Laboratory test or engineering analysis

d. Penetration Seals

(1) Location

TBD

(2) Rating

Wall, floor and ceiling penetrations are sealed to maintain a three hour rating.

(3) Method of Qualification

Laboratory test or engineering analysis

7. Method of Communication to Control Room/Public Address

TBD

8. Personnel Egress/Fire Brigade Access

a. Primary

TBD

b. Secondary

TBD

c. Emergency Lighting

Emergency lighting will be provided in this area per NFPA 101.

9. Potential Effects of Fixed Automatic Suppression System

Not Applicable

10. Potential Effects of Fire Brigade Activities

a. Water Spray

TBD

b. Particles of Combustion

TBD

11. Radiological Consequences of Fire

Not applicable

12. Smoke Control Methods

A smoke purge system is provided to remove products of combustion in the event of a fire in the area. During smoke purge, the smoke purge fan is started and the area is supplied with make-up air to provide a once through ventilation system. The smoke purge mode of operation is manually activated by the control room operator.

13. Summary of Fire Protection Features

a. Active Systems

(1) Primary

Smoke detection

(2) Secondary

Fire extinguisher and fire hose

b. Passive Systems

Fire barriers

c. Defense-in-Depth

The defense-in-depth philosophy involves a combination of fire barriers and manual suppression systems (i.e. hose lines and extinguishers).

14. Consequences of Fire

a. With Detection & Alarm Systems Functioning

The smoke detection system alarms to indicate particles of combustion present in the area. Combustibles are such that a slow growth fire is expected so that the possibility of extinguishing a small fire with an extinguisher is good. The fire brigade responds to insure no smoldering material is left or to use the hose line to extinguish a fire that becomes too intense.

b. ..ithout Detection & Alarm Systems Functioning

A fire in the area could possibly cause loss of equipment if the smoke detection system did not function. The redundant equipment is located in Fire Area 116 (Division I Channel C). The Fire Areas 116 and 120 are separated by multiple layers of three hour fire rated barriers.

15. Compliance with Design Basis

The fire protection features for Fire Area 120 achieve the Design Basis Goals outlined CESSAR-DC Section 9.5.1 "Fire Protection Systems."

THIS NUMBER IS RESERVED
FOR FUTURE ASSIGNMENT

ATTACHMENT 11

TABLE OF CONTENTS (Cont'd)

CHAPTER 2

2.5.2.5 Seismic Wave Transmission Characteristics of the Site

2.5.2.5.1 Control Motion

The Control Motion design response spectra are anchored to a 0.3g peak ground acceleration. They were developed with the objective of being in full compliance with the SRP requirements as well as the EPRI ALWR recommendations report. Again, to cover a maximum range of possible sites where the System 80+ standard design may be constructed, three separate control motion spectra were developed. These are:

A. Control Motion Spectrum 1 (CMS1): This spectrum is included for application at the free-field ground surface. It is identical to Regulatory Guide 1.60 (R.G. 1.60) spectrum and it is considered in order to cover sites with deep soil deposits. Furthermore, because CMS1 is a standardized response spectrum shape, it is considered as the control motion for both rock and soil sites.

B. Control Motion Spectrum 2 (CMS2): This is a rock outcrop spectrum and is developed to cover sites typical of Eastern North America which could be subjected to earthquakes with high frequency content.

C. Control Motion Spectrum 3 (CMS3): This is a rock outcrop spectrum and is developed based on recommendations of the NUREG/CR-0098 (Reference 4) primarily to cover lower frequency motions which may not be covered by CMS2. It is also greatly enhanced in the high frequency range to cover earthquakes with high frequency content. The maximum spectral acceleration range is extended to 15 Hz, as opposed to 8 Hz which is used in NUREG/CR-0098 motions.

All of the above Control Motion Spectra are shown in Figure 2.5-5. All three motions (CMS1, CMS2, ~~AND~~ and CMS3) are used for application at rock sites. For soil sites, CMS2 and CMS3 are intended for application at the rock outcrop, and CMS1 is intended for application at the free-field ground surface. All three motions are applied to each of the 13 sites to conservatively cover all combinations.

The logic for selection process of each of these control motion spectra is described in more detail below:

Selection Process for CMS1

The spectrum shape corresponding to this control motion is as per the requirements of R.G. 1.60. This spectrum shape is chosen in order to be in full compliance with the SRP Section 2.5 requirements as well as the EPRI ALWR recommendations, and is intended to cover deep soil sites.

The control motion is anchored to a peak ground acceleration of 0.3g for the two horizontal directions and the vertical direction.

Selection Process for CMS2

The spectrum shape corresponding to this control motion is for application at the rock outcrop surface, is an 84 percentile curve, and is developed considering NUREG/CR-0098 recommendations as well as ground motions deemed appropriate for the Eastern North American continent. The intent of this spectral shape is to cover various soil sites over-laying a competent material as well as having rock outcrop motion characteristics typical of Eastern North America. The construction of this spectrum shape is shown in Figure 2.5-6. As can be noted from this figure, the spectral ordinates were kept equal to those obtained using NUREG/CR-0098 for frequencies lower than 3.3 Hz, with maximum ground velocity of 24 in/sec/g, which again is typical of expected earthquakes for the Eastern United States. For higher frequencies, particularly above 10 Hz, the selected spectral ordinates are based upon ground motion estimates appropriate for Eastern North America and, as can be seen, are signi-ficantly higher than those obtained using the NUREG/CR-0098.

This control motion is anchored to a peak ground acceleration of 0.3g and peak ground velocity of 7.2 in/sec for the two horizontal directions. In the vertical direction, the control motion is anchored to a peak ground acceleration of 0.2g and peak ground velocity of 4.8 in/sec. The selection of 0.2g at the rock outcrop for the vertical direction leads to vertical spectra at the ground surface that equal or exceed the horizontal spectra at the ground surface over a significant range of frequencies for most of the soil cases.

Selection Process for CMS3

The spectrum shape corresponding to this control motion is developed for application to rock outcrop surface, is an 84 percentile curve, and is in full compliance with the recom-mendations of NUREG/CR-0098 with maximum ground velocity of 36 in/sec/g representing typical sites in Western North America. CMS3 is greatly enriched in the high frequency end of the spectrum to cover earthquakes with high frequency content. The maximum spectral acceleration range extends from 2.2 Hz to 15 Hz. Again, this control motion is anchored to a peak ground acceleration of 0.3g for the two horizontal directions and 0.2g for the vertical direction.

2.5.2.5.3 Site Acceptance Criteria

The CMS1, CMS2, and CMS3 control motions were developed for application in the seismic design of the System 80+ Standard Design. As discussed in Section 2.5 B, for a site to be acceptable for construction, the COL applicant must meet the

Move to new Section 2.5.2.5.3 following Section 2.5.2.5.2

Included in new Section 2.5.2.5.3

acceptance criteria for the SSE control motion, as outlined in Figure 2.5-38. According to these acceptance criteria:

1. For a rock site, the COL applicant will develop site-specific response spectra at 5% damping for the horizontal and vertical directions, and compare them to the envelope of the CMS1, CMS2, and CMS3 control motions (all with 5% damping).

   If the site-specific response spectra are enveloped by the envelope of the CMS1, CMS2, and CMS3 response spectra, the site is acceptable for construction.

   If the site-specific spectra exceed the envelope of the CMS1, CMS2, and CMS3 response spectra at any frequency range, a limited site-specific evaluation will be performed. Then, in-structure response spectra at six critical locations obtained from the limited site-specific evaluation will be compared to the design response spectra (envelope of all generic rock and soil cases). If the in-structure spectra from the site-specific evaluation are within 10% of the envelope of the in-structure design spectra for each of the six locations, the System 80+ is certified for the site. If the in-structure spectra from the site-specific evaluation exceed the envelope of the in-structure design spectra for each of the six locations by more than 10% at any frequency range, a confirmatory site-specific evaluation must be performed.

   The critical locations are:

   a. Foundation Basemat Elevation +50 ft.
   b. Interior Structure Elevation +91.75 ft.
   c. Control Room Elevation +115.5 ft. (Areas 1 and 2)
   d. Top of Steel Containment Vessel Elevation +251 ft.
   e. Interior Structure Elevation +146 ft.
   f. Shield Building Elevation +263.5 ft.

2. For a deep or shallow soil site, the COL applicant will develop site-specific response spectra at 5% damping for the horizontal and vertical directions at the free-field ground surface. The site-specific free-field surface spectra will then be compared to the envelope of the CMS1 spectra and the surface spectra from CMS2 and CMS3 control motions (all with 5% damping). These envelope ground surface spectra are shown in Figures 2.5-39 and 2.5-40 for the horizontal and the vertical directions, respectively.

   If the site-specific surface spectra are enveloped by the envelope of the CMS1 spectra and the surface spectra from CMS2 and CMS3, the site is acceptable for construction.

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Included in new Section 2.5.2.5.3

If the site-specific spectra exceed the envelope of the CMS1 spectra and surface spectra from CMS2 and CMS3 at any frequency range, a limited site-specific evaluation will be performed. Then, in-structure response spectra at six critical locations obtained from the limited site-specific evaluation will be compared to the in-structure design response spectra (envelope of all generic rock and soil cases). If the spectra from the site-specific evaluation are within 10% of the envelope of the design spectra for each of the six locations, the System 80+ is certified for the site. If the spectra from the site-specific evaluation exceed the envelope of the design spectra for each of the six locations by more than 10% at any frequency range, a confirmatory site-specific evaluation must be performed.

The same critical locations as outlined in Item 1 above are used.

Synthetic Time Histories

Synthetic time histories were generated for each of the components, Horizontal-1, Horizontal-2 and Vertical, of each of the control motions CMS1, CMS2 and CMS3, respectively. The spectral ordinates calculated for each synthetic time history and the corresponding smooth spectra are shown in Figures 2.5-7 through 2.5-9 for the CMS2 motion, Figures 2.5-28 through 2.5-30 for the CMS1 motion, and Figures 2.5-31 through 2.5-33 for the CMS3 motion. The spectral ordinates of each synthetic time history conservatively envelop the target smooth spectra at a sufficient number of frequency points to satisfy the SRP Section 2.5 criteria for development of synthetic time histories.

The characteristics of each synthetic time history (accelerogram, velocity and displacement time histories and Power Spectral Density (PSD)) are presented in Appendix 2B. The average PSD of CMS1 fully complies to the SRP Section 3.7.1, Appendix A guidelines for Power Spectral Densities of motions that are based on a Regulatory Guide 1.60 spectral shape. For all three motions CMS1, CMS2 and CMS3, the synthetic time histories in the three directions are statistically independent with correlation coefficients less than 0.2.

2.5.2.5.2 Generic Soil Sites

Generic soil sites were selected by first choosing four generic site categories. These categories were chosen to represent appropriate total thickness of soil overlying bedrock. The four categories are shown schematically in Figure 2.5-1. Site Category A consists of 52 feet of soil overlying bedrock; 52 feet is the embedment depth selected for the System 80+. The soils in site Category B extend to a depth of 100 feet and those in Categories C and D extend to depths of 200 and 300 feet, respectively.

One case was selected for Category A and one case for Category D; these were designated Case A-1 and Case D-1. Four cases were initially selected for site Category B; these were designated Cases B-1, B-2, B-3 and B-4. Three cases were initially selected for site Category C; these were designated Cases C-1, C-2 and C-3. Upon examination of the results of the response analyses for these cases, three additional cases were added. The additional cases were designated Cases B-1.5, B-3.5 and C-1.5. These latter cases were selected to provide an estimate of the response at frequencies that were not considered to be adequately covered by the other cases.

The variations of maximum shear wave velocities with depth assigned for each case are summarized in Appendix 2A Figures 2A-2 through 2A-13. The shear wave velocity distribution with depth was selected to provide a reasonably wide range and also to provide significant contrast in velocities at certain depths for a selected number of cases. The range of maximum shear wave velocities used for all the cases considered in this study is presented in Figure 2.5-2. More details about each case are given in Appendix 2B.

The variation of shear modulus with shear strain was based on using the upper curve from the range published by Seed and Idriss (Reference 5) as shown in Figure 2.5-3. The variations of damping with shear strain was based on the lowered curve from the range published by the same authors, as shown in Figure 2.5-4.

Insert 2.5.2.4

2.5.2.3

2.5.2.6 Safe Shutdown Earthquake

For the Safe Shutdown Earthquake (SSE), the following Peak Ground Accelerations (PGA) were considered:

CMS1 motion:

Horizontal PGA = 0.3g
Vertical PGA = 0.3g

CMS2 motion:

Horizontal PGA = 0.3g
Vertical PGA = 0.2g

CMS3 motion:

Horizontal PGA = 0.3g
Vertical PGA = 0.2g

Insert 2.5.2.5.4

2.5.2.5.4 Site Specific Seismic Spectra

The COL applicant will be required to develop site-specific seismic design response spectra for use in the design and qualification of site-specific structures, systems, and components not included in the design certification scope for System 80+ standard plants. The following criteria shall be used in developing the minimum site-specific seismic design requirement

1. The horizontal and vertical free-field ground surface site-spec'fic response spectra shall be developed using approved NRC procedures.

2. The System 80+ certified design horizontal and vertical Regulatory Guide 1.60 design response spectrum shapes anchored to 0.30g peak ground acceleration shall be scaled throughout their entire frequency range such that the minimum spectral amplitudes of the certified design spectra are equal to the maximum spectral amplitudes of the horizontal and vertical site-specific ground motion spectra, respectively, in the 5 to 10 hertz frequency range.

3. The resulting design response spectra shall be defined as the minimum seismic design requirement for design and qualification of site specific structures, systems, and components for the System 80+ standard plant.

LIST OF FIGURES

APPENDIX 2B

LIST OF FIGURES (Cont'd)

APPENDIX 2B

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APPENDIX 2B

CHARACTERISTICS OF SELECTED CONTROL MOTIONS

ABSTRACT

The synthetic time histories generated to represent the horizontal components H1, H2 and the vertical component of control motions CMS1, CMS2 and CMS3 are presented in this Appendix.

The acceleration, velocity and displacement time histories of control motion CMS1 are shown in Figures 2B-1 through 2B-3. The average Power Spectral Densities (PSD) of the CMS1 synthetic time histories are shown in Figures 2B-4 and 2B-5.

The acceleration, velocity and displacement time histories of control motion CMS2 are shown in Figures 2B-6 through 2B-8, 2B-10 through 2B-12, and 2B-14 through 2B-16. The Power Spectral Densities (PSD) of the CMS2 synthetic time histories are shown in Figures 2B-9, 2B-13 and 2B-17.

The acceleration, velocity and displacement time histories of control motion CMS3 are shown in Figures 2B-18 through 2B-20. The average Power Spectral Densities (PSD) of the CMS3 synthetic time histories are shown in Figures 2B-21 through 2B-23.

The selection process for CMS1, CMS2 and CMS3 are given in Section 2.5.2.5.1.

*

and their respective target PSDs

Insert 1

Insert 1

The average PSDs for the CMS1, CMS2 and CMS3 control time histories are developed using the procedure described in SRP, Section 3.7.1, Appendix A. The target PSD for CMS1 (horizontal) motion (Reg. Guide 1.60 horizontal) is obtained directly from SRP, Section 3.7.1, Appendix A. The methodology for the development of the target PSDs for CMS1 (vertical), CMS2 and CMS3 is described below.

<u>Methodology for Development of Target Power Spectral Densities</u>

The development of target PSDs for CMS1 (vertical), and the rock outcrop motions CMS2 and CMS3 is performed using principles of Random Vibration Theory (RVT). Details of this method as well as the mathematical formulation are described in References 1 and 2. The basic approach is that the target PSD is developed by an iterative process. At each step of the iteration, the PSD is refined to produce a spectrum that closely matches the target response spectrum. Adjustments to the PSD are made at the frequency ranges that do not produce a close spectral match, and the final target PSD is obtained when the desired spectrum convergence is achieved. The minimum check is set at 80% of the target PSD, consistent with SRP guidelines.

The development of the target PSDs is performed using the 2% damped spectrum as the target spectrum ~~of~~ for each control motion.

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REFERENCES FOR APPENDIX 2B

1. Boore, D. M., "Stochastic Simulation of High-Frequency Ground Motions Based on Seismological Models of the Radiated Spectra", Bulletin of the Seismological Society of America, Volume 73, Number 6, pp. 1865-1894.

2. Boore, D.M., and Joyner, W.B., "A Note on the Use of Random Vibration Theory to Predict Peak Amplitudes of Transient Signals", Bulletin of the Seismological Society of America, Volume 74, Number 5, pp 2035-2039, October 1984.

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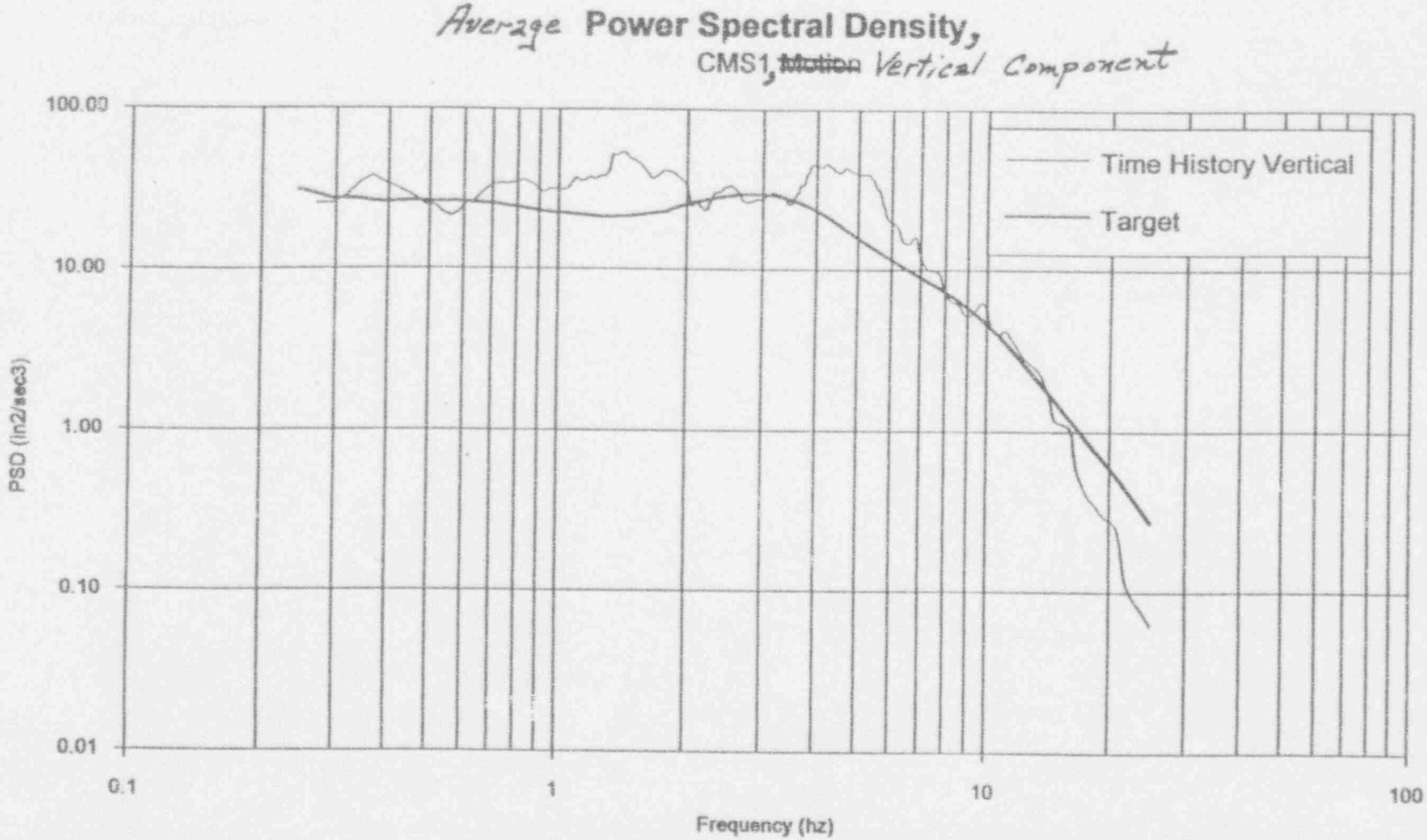
Figure 2B-5



Average Power Spectral Density,
CMS1, ~~Motion~~ Vertical Component
Time History Vertical
Target
100.00
10.00
1.00
0.10
0.01
PSD (in2/sec3)
0.1
1
10
100
Frequency (hz)

V

Figure 2B-9

Average **Power Spectral Density,**
CMS2, ~~Motion~~ *Component H1*

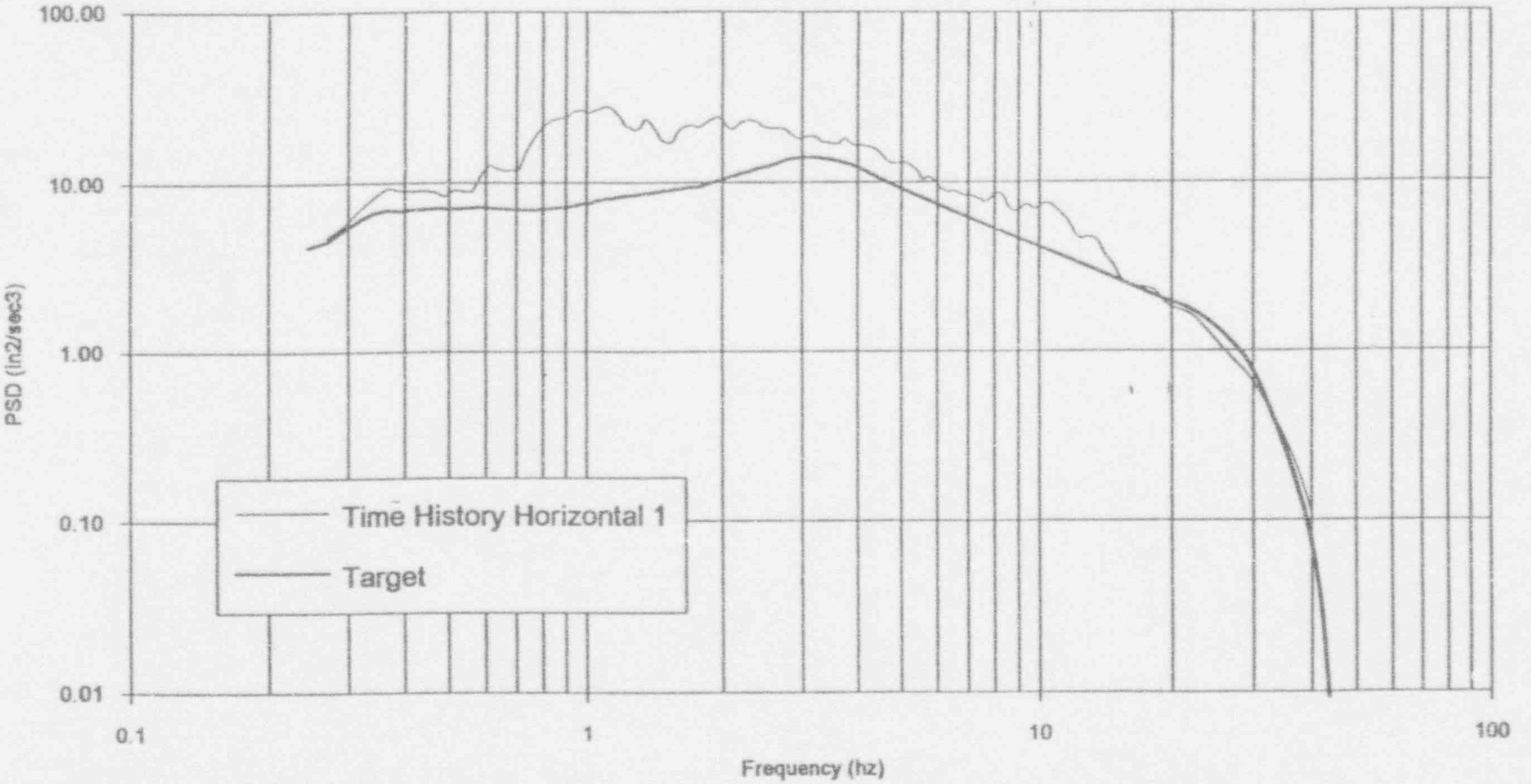


Figure 2B-13

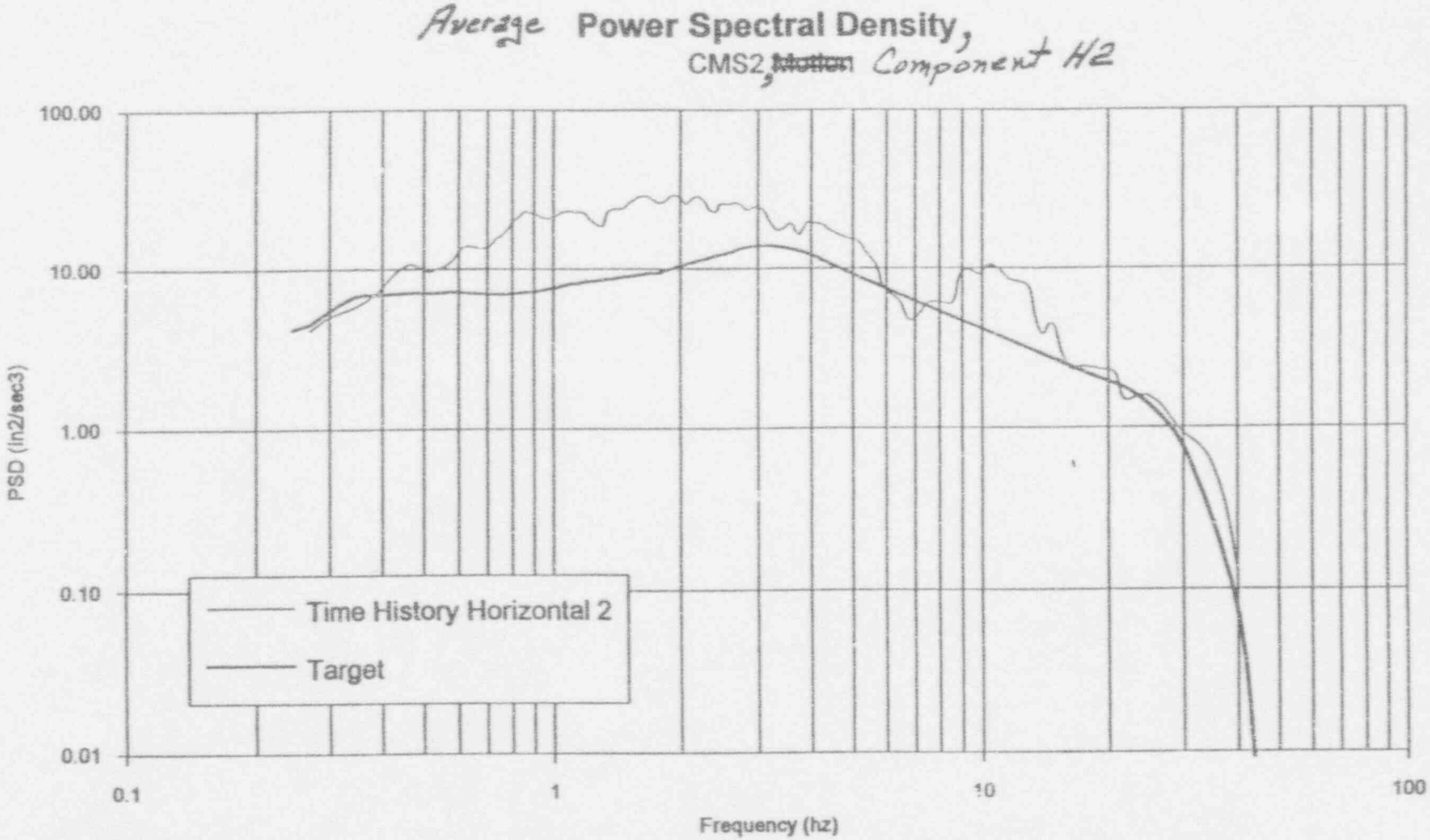
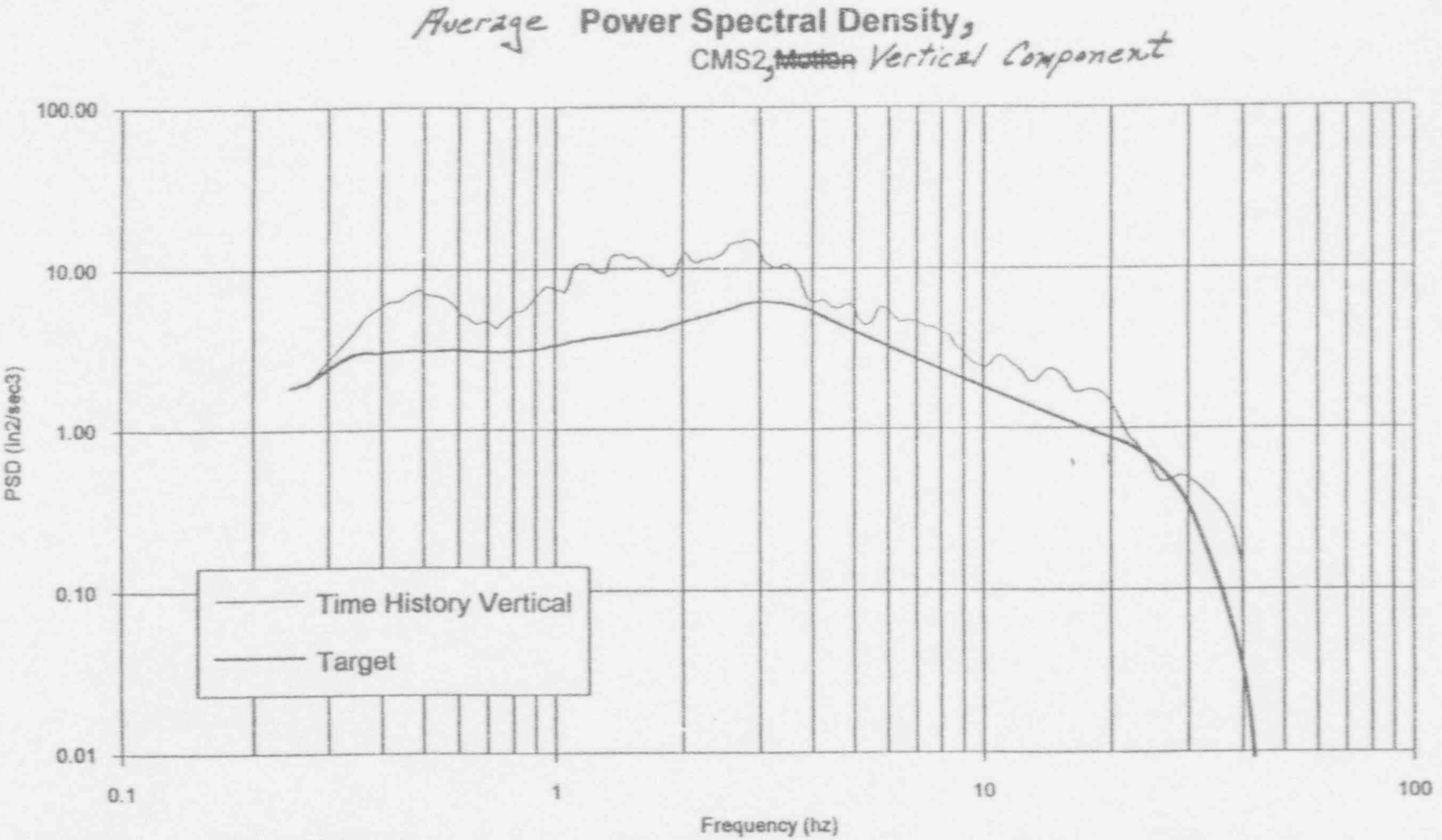

Average Power Spectral Density,
CMS2, ~~Motion~~ Component H2
100.00
10.00
1.00
0.10
0.01
PSD (in2/sec3)
0.1
1
10
100
Frequency (hz)
Time History Horizontal 2
Target

Figure 2B-17



V

Figure 2B-21

Average **Power Spectral Density,**
CMS3, ~~Motion~~ Component H1

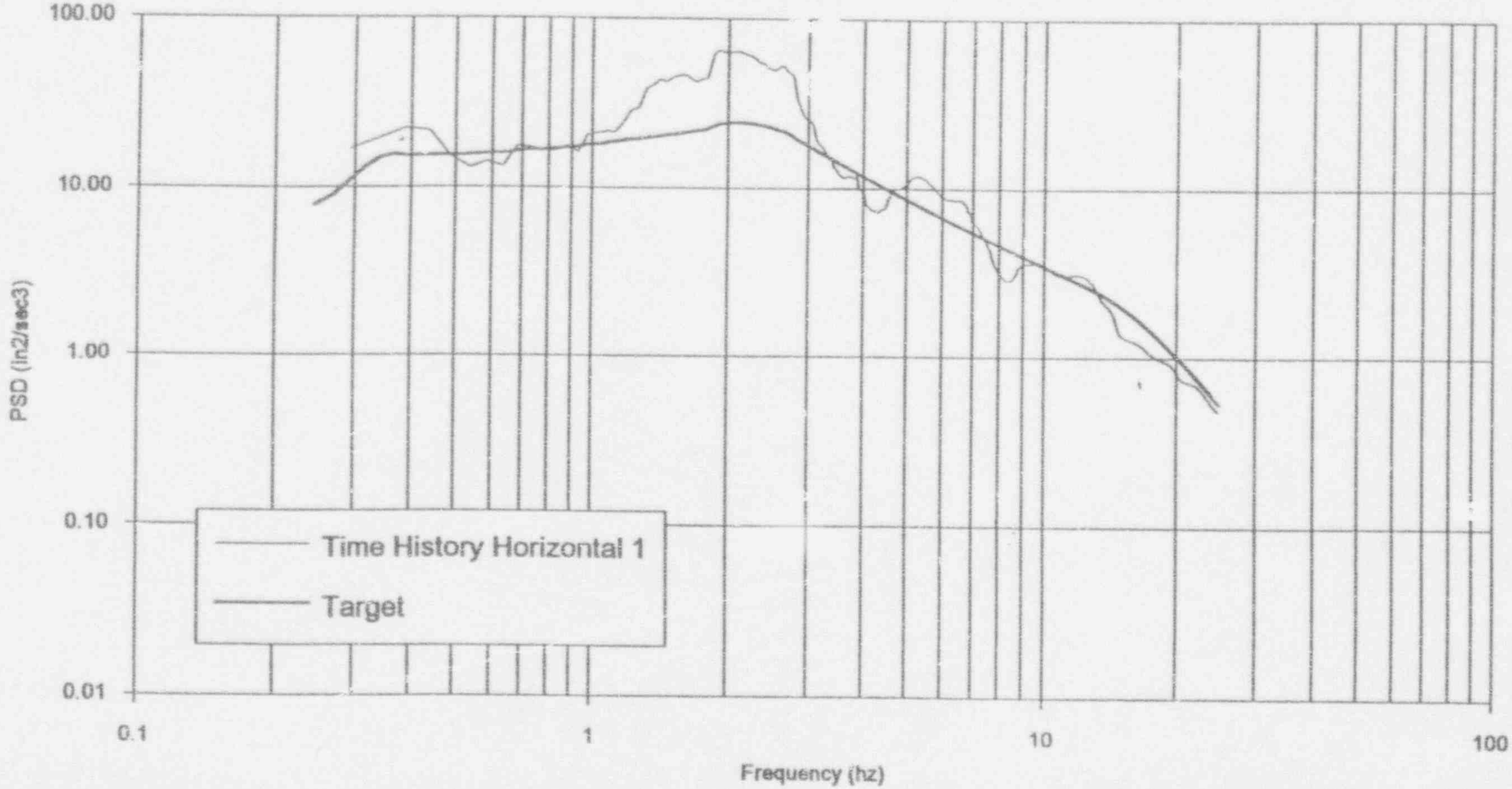


Figure 2B-22

Average Power Spectral Density,

CMS3, ~~Motion~~ Component H2

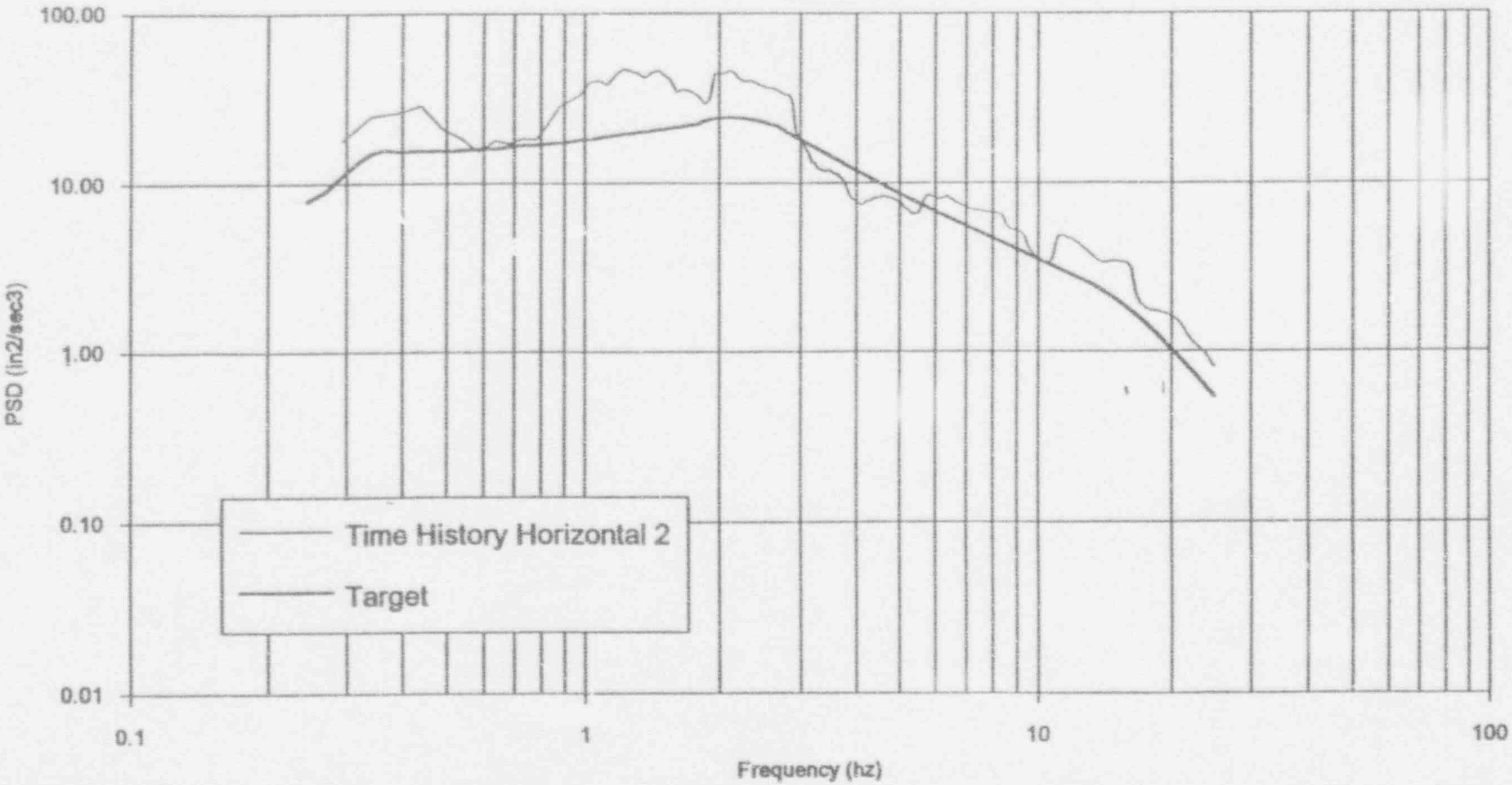


Figure 2B-23

Average **Power Spectral Density,**
CMS3, ~~Motion~~ Vertical Component

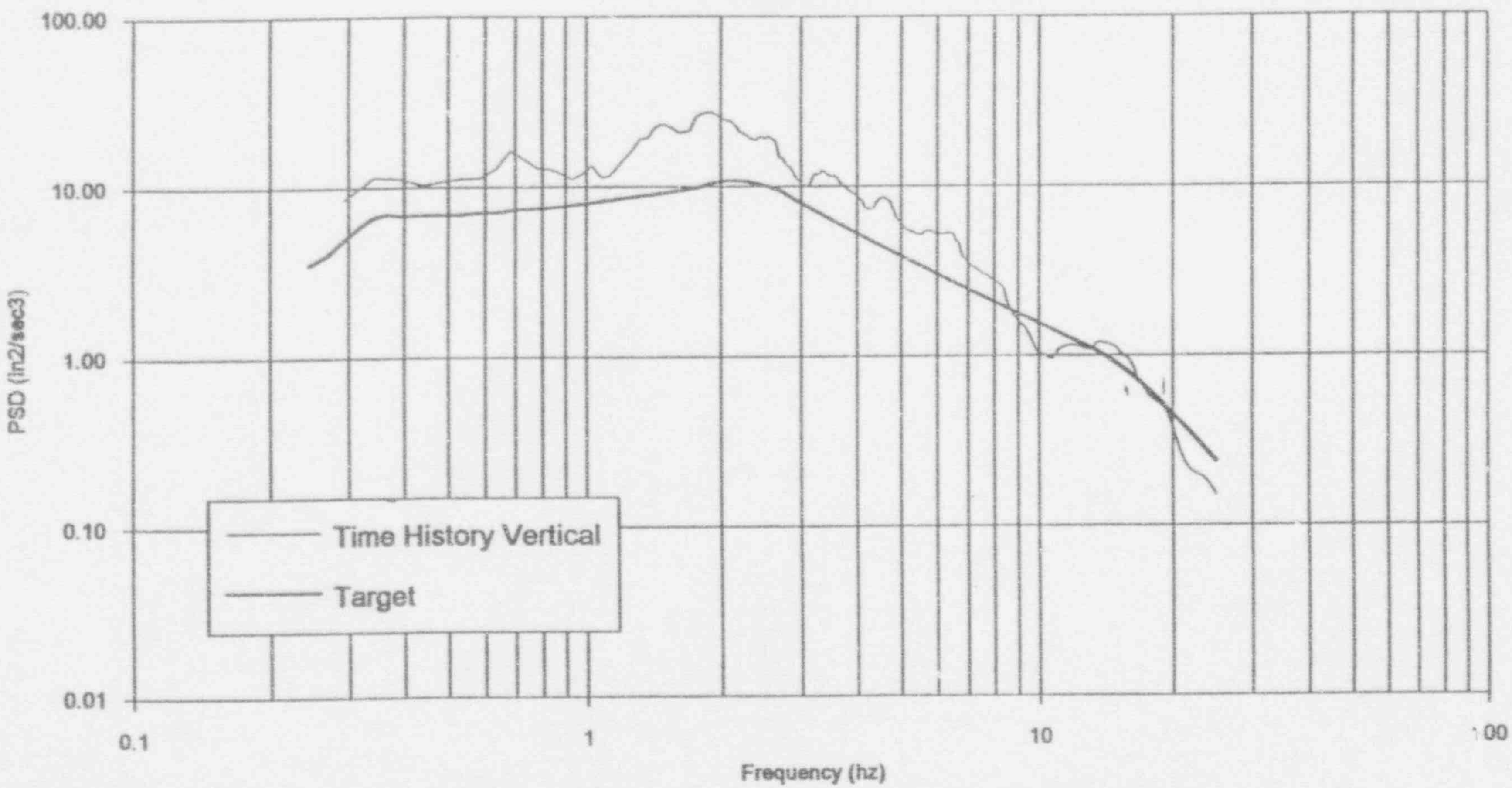


TABLE OF CONTENTS (Cont'd)

CHAPTER 3

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CHAPTER 3

TABLE 3.2-1 (Cont'd)

(Sheet 22 of 26)

CLASSIFICATION OF
STRUCTURES, SYSTEMS, AND COMPONENTS

Component Identification	Safety Class	Seismic Category	Location	Quality Class
Nuclear Annex				
Control Area	3	I	NA	1
EFW Tank/Main Steam Valve House Area	3	I	NA	1
Emergency Diesel Generator Areas	3	I	NA	1
CVCS/Maintenance Area	3	I	NA	1
Fuel Handling Area	3	I	NA	1
Unit Vent	NNS	II	NA/RB	2
Turbine Building	NNS	II	TB	2
Radwaste Building (28)	NNS	II	RW	2
Station Service Water Pump/Intake Structure	3	I	SP	1
Component Cooling Water Heater Exchanger Structures and Pipe Tunnels	3	I	CX/YD	1
Diesel Fuel Storage Structure	3	I	DF	1
Station Services Building/Auxiliary Boiler Structure	NNS	NS	SB	3
Administration Building	NNS	NS	ADB	3
Warehouse	NNS	NS	WH	3
Fire Pump House	NNS	NS	FP	3
Dike (Holdup, Boric Acid Storage and Reactor Makeup WaterTanks) (28)	NNS	II	YA	2
Dike (Condensate Storage Tank) (28)	NNS	II	YA	2
Cranes				
Polar Crane	NNS	II	RC	2
Cask Handling Hoist	NNS	II	NA	2
New Fuel Handling Hoist	NNS	II	NA	2
Component Supports (23)	1/2/3/NNS	I/NS	ALL	1/2/3

Maximum wind speed:	330 mph
Rotational speed:	260 mph
Translational velocity:	70 mph
Radius:	150 feet
Maximum pressure differential:	2.4 psid
Rate of pressure drop:	1.7 psi/second
Missile Spectra:	See Table 3.5-2

3.3.2.2 Determination of Forces on Structures

The forces on Seismic Category I structures due to tornado wind loadings are obtained using methods outlined in Section 3.3.1.2, with a wind velocity of 330 mph (vector sum of all component velocities - assumed constant with height). Velocity profiles are determined as outlined in Section 3.3.1.1. Effective pressure distribution loads are transformed into equivalent static building forces as outlined in Section 3.3.1.2. In determining tornado wind loadings, both the importance factor and gust factors are taken as unity.

Tornado loadings include tornado wind pressure, internal pressure due to tornado created atmospheric pressure drop, and forces generated due to the impact of credible tornado missiles. These loadings are combined with other loads as described in Section 3.8.

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3.3.~~2.3~~ 3 Effect of Failure of Structures or Components Not Designed for Wind and Tornado Loads

Adjacent structures, systems and components exposed to wind and tornado loads will not be permitted to affect or degrade the capability of Seismic Category I structures, systems and components to perform their intended safety functions. ~~as a result of tornado loadings.~~ This is accomplished by one of the following methods:

A. Designing the adjacent structure, system or component to Seismic Category I wind and tornado loadings.

B. Investigating the effect of adjacent structural failure on Seismic Category I structures, systems and components to determine that no impairment of function results.

C. Designing a structural barrier to protect Seismic Category I structures, sytems and components from adjacent structural failure.

lengths of piping runs. The RB Subsphere also provides for close proximity of equipment to reduce piping runs from containment.

Flood barriers have been integrated into the design to provide further flood protection while minimizing the impact on maintenance accessibility. The primary means of flood control in the Nuclear Annex and RB Subsphere is provided by the divisional wall which serves as a barrier between redundant trains of safe shutdown systems and components. Each half of the Subsphere is further divided into two quadrants to separate redundant safe shutdown components to the extent practical. Flood barriers provide separation between Subsphere quadrants, while maintaining equipment removal capability. Emergency Feedwater pumps are located in separate compartments within the quadrants with each compartment protected by flood barriers.

Penetrations are sealed and no doors are provided up to EL. 70+0, the maximum internal flood in the divisional wall that separates the Nuclear Annex and the Reactor Building Subsphere. Where flood doors are provided, open and close sensors are also provided with status indication. Flood barriers also provide separation between electrical equipment and fluid mechanical systems at the lowest elevation within the Nuclear Annex. At higher elevations, safety-related electrical components are elevated above the floor so that flooding events will not affect components. Additional barriers (e.g., curbs, sealed penetrations) are provided or safety-related electrical components are elevated, as necessary, to mitigate the effects of postulated pipe rupture addressed in Section 3.6.

Flood protection is also integrated into the floor drainage system. The floor drainage systems are separated by division and Safety Class 3 valves are provided to prevent backflow of water to areas containing safety-related equipment. Each subsphere quadrant is provided with redundant Safety Class 3 sump pumps and associated instrumentation, which are powered from the diesel generators in the event of loss of offsite power.

The Nuclear Annex floor drainage system is divisionally separated, with no common drain lines between divisions. Floors are gently sloped to allow good drainage to the divisional sumps.

Insert to 3.4

Flood protection is incorporated into the Component Cooling Water Heat Exchanger Structure. This structure is divisionally separated by a wall such that a flood in one division can not flood the other division.

The Diesel Generator Building floor drain sump pumps and associated instrumentation are Safety Class 3 to prevent flooding of the diesel generators. These pumps are also powered from the diesel generator in the event of loss of offsite power.

Insert to section 3.4

97 No water lines are routed above or through the control room and the computer room. HVAC water lines contained in rooms around the control room are located in rooms with raised curbs to prevent leakage from entering the control room. Y

Given the separation criteria above, and the pipe break criteria in Section 3.6.2.1.2, the effects of high-energy pipe breaks are not analyzed where it is determined that all essential systems, components, and structures are sufficiently physically remote from a postulated break in that piping run.

3.6.2 DETERMINATION OF BREAK LOCATIONS AND DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING

Described herein are the design bases for locating breaks and cracks in piping inside and outside containment, the procedure used to define the thrust at the break location, the jet impingement loading criteria, and the dynamic response models.

The COL applicant will provide final designs of high- and moderate-energy fluid systems. The final designs and results of high- and moderate-energy piping analyses will be documented in a pipe break analysis report. An inspection of the as-built high-energy piping systems will be performed. The inspection of the as-built high energy pipe break features shall be performed to verify: INSERT 3.6.2 V

- The location of pipe break mitigation devices (restraints, jet shields)
- Clearances/gaps between restraints and piping
- The location of nearby safety-related targets to be protected from high-energy line breaks.

Any differences between the as-built information and the as-designed information will be reconciled and documented in a pipe break analysis report.

3.6.2.1 Criteria Used to Define Break and Crack Locations and Configurations

3.6.2.1.1 General Requirements

Postulated pipe ruptures are considered in all plant piping systems and the associated potential for damage to required systems and components is evaluated on the basis of the energy in the system. System piping is classified as high-energy or moderate-energy, and postulated ruptures are classified as circumferential breaks, longitudinal breaks, leakage cracks, or through-wall cracks. Each postulated rupture is considered separately as a single postulated initiating event.

INSERT TO 3.6.2

The Pipe Break Analysis Report shall provide the results of the pipe break analyses. These analyses shall be based on criteria used to postulate cracks and breaks in high- and moderate-energy piping systems as defined in Section 3.6.2 and shall employ the analytical methods described in Section 3.6.2 and Appendix 3.6A.

For postulated pipe breaks, the Pipe Break Analysis Report shall confirm that:

(1) piping stresses in the containment penetration area are within their allowable stress limits,

(2) pipe whip restraints and jet shield designs are capable of mitigating pipe break loads, and

(3) loads on safety-related systems, structures and components are within their design load limits.

The Pipe Break Analysis Report shall also confirm that structures, systems and components required for safe shutdown can withstand the environmental effects of postulated cracks and breaks.

Irrespective of the fact that the criteria in Section 3.6.2 may not require specific breaks, if a structure outside containment separates a high-energy line from an essential component, that separating structure is designed to withstand the consequences of the pipe break in the high-energy line that produces the greatest effect on the structure. Structures inside containment which are used to separate high-energy lines from essential components are designed to withstand the dynamic load effects of postulated pipe breaks not eliminated by leak-before-break. In addition, these structures inside containment are adequately designed to withstand the greatest effect from (1) pipe breaks not eliminated by leak-before-break, (2) the largest through-wall leakage crack in the high-energy line (minimum 10 gpm) whether or not consideration of dynamic effects is eliminated by LBB for that line, or (3) the largest leak from another leak source, such as a valve or pump seal.

3.6.2.1.2 Postulated Rupture Descriptions

A. Circumferential Break

A circumferential break is assumed to result in pipe severance with full separation of the two severed pipe ends unless the extent of separation is limited by consideration of physical means. The break plane area (A_e) is assumed perpendicular to the longitudinal axis of the pipe, and is assumed to be the cross-sectional flow area of the pipe at the break location. The break flow area (A_f) from each of the broken pipe segments for a circumferential break, with full separation of the two broken pipe segments, is equal to the break plane area (A_e). The break flow area, discharge coefficient and discharge correlation are substantiated analytically or experimentally.

B. Longitudinal Break

A longitudinal break is assumed to result in a split of the pipe wall along the pipe longitudinal axis, but without severance. The break plane area (A_e) is assumed parallel to the longitudinal axis of the pipe and equal to the cross-sectional flow area of the pipe at the break location. The break flow area (A_f) is equal to the break plane area (A_e). The break is assumed to be circular in shape or elliptical (2D x D/2) with its long axis parallel to the axis. The discharge coefficient and any other values used for the area or shape associated with a longitudinal break are substantiated analytically or experimentally.

C. Leakage Crack

A leakage crack is assumed to be a crack through the pipe wall where the size of the crack and corresponding flow rate are determined by analysis and a leak detection system, as described in Section 3.6.3.

For hand calculation the break mass flow rate is obtained from a critical flow correlation which predicts an upper bound flow rate for the rupture geometry and fluid state under consideration. Examples are the Moody correlation (two-phase and saturated steam conditions), the Homogeneous Equilibrium Model (single phase steam), and the Henry-Fauske correlation (subcooled liquid). Blowdown flow rate is obtained from the following equation per ANSI/ANS-56.10:

$W = C_D A G_C$ where: W = mass flow rate
C_D = discharge coefficient
A = break area
G_C = critical mass flux

The break fluid enthalpy is set equal to the stagnation enthalpy of the fluid in the ruptured pipe. A flow discharge coefficient of 1.0 is used unless a lower value is justified as required by ANSI/ANS-56.10.

For complex systems and where less conservative release rates are needed, computer analysis is employed. Initial conditions (e.g., fluid pressure, fluid temperature) are chosen within normal operating limits such that the set which will result in the largest release rates are used. A system model of appropriate complexity is generated and computer programs of the RELAP4 type are used. To calculate the pipe break response, the fluid system is divided into discrete volumes (control volumes or nodes) which are connected to other volumes by a junction. The equations of conservation of mass and energy are solved in the nodes, and the one-dimensional momentum equation is solved in the flow paths. A time history of system conditions is output by the code. CEFLASH-4A (Section 3.9.1.2.1 22), RELAP4/MOD5, and RELAP5/MOD3 IV (Reference 15) are computer codes applicable to the generation of mass and energy releases. Also, SGNIII (Section 6.2.1.4.4) may be used in the case of main steam line breaks.

3.6.2.5.3 21 Compartment Pressurization Analysis and Environmental Pressure and Temperature Analysis

Compartment pressurization analysis is performed to determine pressure loadings on building structures. Environmental pressure and temperature response analysis defines pressure and temperature conditions for qualification of mechanical and electrical equipment.

Computer codes are generally used in some phase of this analysis. Typically the model includes a network of volumes and junctions. volumes represent rooms, corridors, pipe chases, and other portions of buildings outside Containment. When appropriate, volumes also are used to simulate the HVAC system and outside atmosphere. Junctions represent flow paths between the volumes. Multinode analysis may be required within a compartment. The computer codes addressed below provide acceptable results for

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both compartment pressurization and environmental pressure and temperature analyses, with appropriate assumptions and models changed to obtain conservative results.

The DDIFF-1 computer code (Reference 19) is used to predict subcompartment conditions following incident initiation during which the maximum pressure differentials on structures or components would occur. The transient calculations include determination of mass flow rates, mass and energy inventories, absolute and differential pressures, and temperatures in the subcompartment system. The subcompartment system is a control volume-flow path spatial network created based upon the geometry of the plant regions being analyzed.

RELAP4/MOD5, RELAP5/MOD3, and COMPARE may be used for these analyses. Another computer code which may be applied here is the multicompartment containment system analysis code CONTEMPT4/MOD4 (Reference 17). It is used to predict the long-term thermal-hydraulic behavior of a series of standard compartments. The code calculates the time variation of compartment thermodynamic properties, temperature distributions in heat conducting structures, mass and energy inventories in compartments, and mass and energy transfer due to intercompartment junction flow by solving the mass and energy balance equations.

The GOTHIC computer code (Reference 18) is a state-of-the-art program for modeling multiphase flow. It solves the conservation equations for mass, momentum and energy for multicomponent, two-phase flow. The code contain a flexible noding scheme that allows lumped parameter, one-, two, or three-dimensional analysis or any combination of these to be conducted. Conservation equations are solved for three fields: (1) steam-gas mixture (2) continuous liquid, and (3) liquid droplet. It calculates the relative velocities between these fields, including the effects of two-phase slip on pressure drop and heat transfer between phases and between surfaces and the fluid.

3.6.3 LEAK-BEFORE-BREAK EVALUATION PROCEDURE

This section describes Leak-Before-Break (LBB) analysis for all applicable piping. LBB analysis is used to eliminate from the structural design bases the dynamic effects of double-ended guillotine breaks and equivalent longitudinal breaks for an applicable piping system. V

LBB is demonstrated for the following System 80+ piping systems:

1. Main Coolant Loop (MCL) piping, hot and cold legs
2. Surge Line (SL)
3. Direct Vessel Injection (DVI) Line (main run inside containment)
4. Shutdown Cooling Line (SC) (main run inside containment)
5. Main Steam Line (MSL) (main run inside containment)

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2.0 PIPE RUPTURE EVALUATION

2.1 GENERAL APPROACH

The approach used for evaluating the effects of pipe rupture ~~are~~ is based on Reference 4.9. The specific method employed for pipe whip evaluation is generally determined by the nature of the problem and the size and pressure of the line being restrained:

- Energy balance analysis is the simplest form of analysis. Its use is confined to conceptual design and to the evaluation of restraints for small or relatively low pressure lines, especially the qualification of standard small line restraints.
- Simplified dynamic analyses are used to evaluate restraints for small and moderate size lines and to evaluate situations, such as concrete barrier impact, which are evaluated primarily by empirical relationships and which do not lend themselves to more detailed analysis.
- Detailed dynamic analyses are performed for all large line restraints and for the evaluation of containment penetration areas in any size line.

2.2 PROCEDURE FOR ENERGY BALANCE ANALYSIS

Energy balance analysis equates the work done by the blowdown thrust force to the energy absorbed in the restraint. This permits a designer to readily size the energy absorbing component and this approach is often used for initial restraint sizing. The work done is based on a quasi-steady-state fluid force times the distance traveled, including the deflection of the restraint. Energy absorbed by the pipe, as at a plastic hinge, is conservatively ignored. The steady-state fluid forcing function is derived in accordance with Section III.2.c(4) of Reference 4.2. If the approach is used for final design, typically for small lines, the approach follows the requirements of Reference 4.2 and includes an amplification factor of 1.1 on the fluid forcing function to account for a possible maximum reaction beyond the first quarter cycle of response.

2.3 PROCEDURE FOR DYNAMIC ANALYSIS WITH SIMPLIFIED MODELS

Simplified dynamic analysis models involve closed-form solutions for the pipe whip event, as detailed in Reference 4.9. Two forms of analysis are used, both being enhancements of the energy balance approach in which the time domain is explicitly considered. As in energy balance analysis, an amplification factor of 1.1 is applied to the fluid forcing function.

simulate the dynamic characteristics of the models used in that analysis.

The mathematical model provides a three-dimensional representation of the dynamic response of the coupled components to seismic excitations in both the horizontal and vertical directions. The mass is distributed at the selected mass points and corresponding translational degrees of freedom are retained to include rotary inertial effects of the components. The total mass of the entire coupled system is dynamically active in each of the three coordinate directions.

Surge Line

A lumped parameter, multimass mathematical model is employed in the analysis of the surge line. A representative model is shown schematically in Figure 3.7-25. The surge line is modeled as a three-dimensional piping run with end points anchored at the attachments to the pressurizer and the reactor vessel outlet piping. All supports defined for the surge line assembly are included in the mathematical model. The total mass of the surge line is dynamically active in each of the three coordinate directions. The surge line is analyzed as uncoupled from the reactor coolant system, using the motions of the hot leg, pressurizer and supports as input.

3.7.2.1.2.3 Analysis

13

Modeling and analysis of the coupled components of the reactor coolant system and the pressurizer are performed using ANSYS. A description of ANSYS is given in Section 3.9.1.2.1.~~[illegible]~~. Modeling and analysis of the surge line is performed using the SUPERPIPE code, a description of which is given in Section 3.9.1.2.1.4. IV

Time history data for all six possible components of motion are applied simultaneously to the coupled building model to analyze the coupled components of the reactor coolant system.

The responses to seismic excitation for the coupled components of the reactor coolant system are computed using the transient analysis capability of ANSYS. In the analysis of the coupled components of the RCS, excitations are input at selected points in the reactor building. For the coupled components of the RCS, the relative support displacements are inherently accounted for during the coupled analysis. The building motions derived from the soil-structure interaction analysis consist of six time histories at each location per soil case, three linear and three rotational. For each soil case all six time history motions are applied at each selected point of the coupled building model to analyze the coupled components of the RCS. The calculated motions for input to subsequent subsystem analyses therefore include the motions caused by the foundation torsion and rocking.

Where R is the maximum response of a given element, R_K is the peak response of the element due to the K^{th} mode, and N is the number of significant modes.

If some of the modes are closely spaced the response of the individual modes is combined using the Ten Percent Method from Regulatory Guide 1.92. This can be expressed as:

$$R = \left(\sum_{k=1}^{N} R_k^2 + 2 \Sigma \left| R_i R_j \right| \right)^{1/2} \qquad i \neq j$$

Where R, R_K and N are as previously defined. The second summation is performed on all i and j modes whose frequencies are closely spaced to one another. Alternative summation methods given in Regulatory Guide 1.92, such as the Double Sum Method, are acceptable substitutes for the method described above.

3.7.2.7.2 Nuclear Steam Supply System

The SRSS method is the procedure normally used to combine the modal responses when the modal analysis response spectrum method of analysis is employed. The procedure, in accordance with Regulatory Guide 1.92, is modified in two cases:

A. In the analysis of simple systems where three or less dynamic degrees of freedom are involved, the modal responses are combined by the summation of the absolute values method;

B. In the analysis of complex systems where closely spaced modal frequencies are encountered, the responses of the closely spaced modes are combined by the summation of the absolute values method and, in turn, combined with the responses of the remaining significant modes by the SRSS method. Modal frequencies are considered closely spaced when their difference is less than ±10 percent of the lower frequency.

3.7.2.8 Interaction of Non-Seismic Category I ~~Safety Related~~ Structures, Systems and Components with Seismic Category I ~~Safety Related~~ Structures, Systems and Components

Insert 3.7.2.8-1

~~When safety-related and non-safety-related structures are integrally connected, the non safety related structure is included in the model when determining the forces on safety-related structures.~~

To ensure that the failure of a non-Seismic Category I ~~safety related~~ structure, system or component under the effect of a seismic event does not impair the integrity of an adjacent Seismic Category I ~~safety related~~ structure, system or component, the following procedures are used:

A. Sufficient separation between non-Seismic Category I ~~safety related~~ structures, system and components and Seismic Category I ~~safety related~~ structures, system and components is maintained, or

, systems and components

B. The non-~~safety related~~ Seismic Category structures are analyzed and designed to prevent their failure under SSE conditions in a manner such that the margin of safety of these structures is equivalent to that of ~~safety-related~~ Seismic Category I structures.

C. The ~~safety-related~~ Seismic Category I structure is designed to withstand loads due to collapse of the adjacent non-~~safety related~~ Seismic Category I structure should sufficient spatial separation ~~of the structures~~ , system or component not be achieved.

Insert 3.7.2.8-2

3.7.2.9 **Effects of Parameter Variations on Floor Response Spectra**

To account for the expected variation in structural properties, dampings and other parameter variations, the peaks of floor response spectrum curves are broadened by ±15% and smoothed in accordance with Regulatory Guide 1.122.

Soil property related spectrum peaks are further broadened, where required, to conservatively account for all potential variations of soil properties within the envelope of site conditions.

3.7.2.10 **Use of Constant Vertical Static Factors**

A constant seismic vertical load factor is not used for the seismic design of Seismic Category I structures, systems, components and equipment.

The safety-related structures, systems, and components are analyzed in the vertical direction using the methods described in Section 3.7.2.1. Based on the vertical seismic analysis, a vertical static factor is determined to design columns and shear walls. The vertical floor flexibilities are accounted for in the response spectra at each individual floor elevation of the building structures. The floor beams are designed statically for the acceleration value obtained per Reference 1.

3.7.2.11 **Methods Used To Account for Torsional Effects**

The mathematical models used in analysis of Seismic Category I systems, components, and piping systems include sufficient mass points and corresponding dynamic degrees-of-freedom to provide a three-dimensional representation of the dynamic characteristics of the system. The distribution of mass and the selected

Insert 3.7.2.8-1

The interfaces between Seismic Category I and non-Seismic Category I structures, systems and components are designed for the dynamic loads and displacements produced by both the Seismic Category I and non-Seismic Category I structures, systems and components.

Insert 3.7.2.8-2

The COL applicant shall describe the process for the design of plant specific and non-Seismic Category I structures, systems and components to reduce the potential for non-Seismic Category I to Seismic Category I (II/I) interactions and propose procedures for an evaluation of the as-built plant for II/I interactions.

where:

n = total number of components,

β_j = composite modal damping for mode j,

β_i = critical modal damping associated with component i,

ϕ_j = mode shape vector,

$\{M_i\}$ = subregion of mass matrix associated with component i, and

$[M]$ = the mass matrix of the system.

For direct integration method, viscous damping proportional to the mass and stiffness matrix is used; thus

$$[C] = \alpha[K] + \beta[M]$$

where [C] is the damping matrix, [K] is the stiffness matrix and [M] is the mass matrix. The values of α and β are selected such that the damping in the range of frequency of interest is approximately equal to the damping of the structure.

INSERT 3.7.2.15

3.7.3 SEISMIC SUBSYSTEM ANALYSIS

3.7.3.1 Seismic Analysis Methods

The seismic analysis of the Seismic Category I structures, subsystems, and components other than piping is performed by either the response spectrum or time history method as described in Section 3.7.2.1.1 or an equivalent static method described in Section 3.7.3.5.

When analyzed using the response spectrum method, four options are available for the choice of response spectra. These are described in Appendix 3.9A, Section 1.4.3.2.1.2. Appendix 3.7D shows sample spectra for use in the three options not related to plant specific analysis.

For Seismic Category I piping, each piping system is idealized as a mathematical model consisting of lumped masses connected by elastic members. The stiffness matrix for the piping subsystem is determined using the elastic properties of the pipe. This includes the effects of torsional, bending, shear, and axial deformations as well as changes in stiffness due to curved members. Generally, a response spectrum analysis is performed using the envelope of all applicable spectra to account for inertia effects. The effects of rocking and torsion are implicitly included because the spectra at the support points

INSERT 3.7.2.15

¶ Where composite modal damping is used for piping, the input damping for piping elements is in accordance with Table 3.7-1. That is, for the Safe Shutdown Earthquake, the damping is 2.0 percent of critical damping for piping of diameter $\leq$ 12 inches and is 3.0 percent of critical damping for piping of diameter > 12 inches.

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APPENDIX 3.7B

Figure 3.7C-3

~~CE System 80+~~ Response Spectra at Elev. 73.75' of CCW, All Soil Cases, All Motions, Horizontal Model, H2 Motion (N-S), 2% Damping

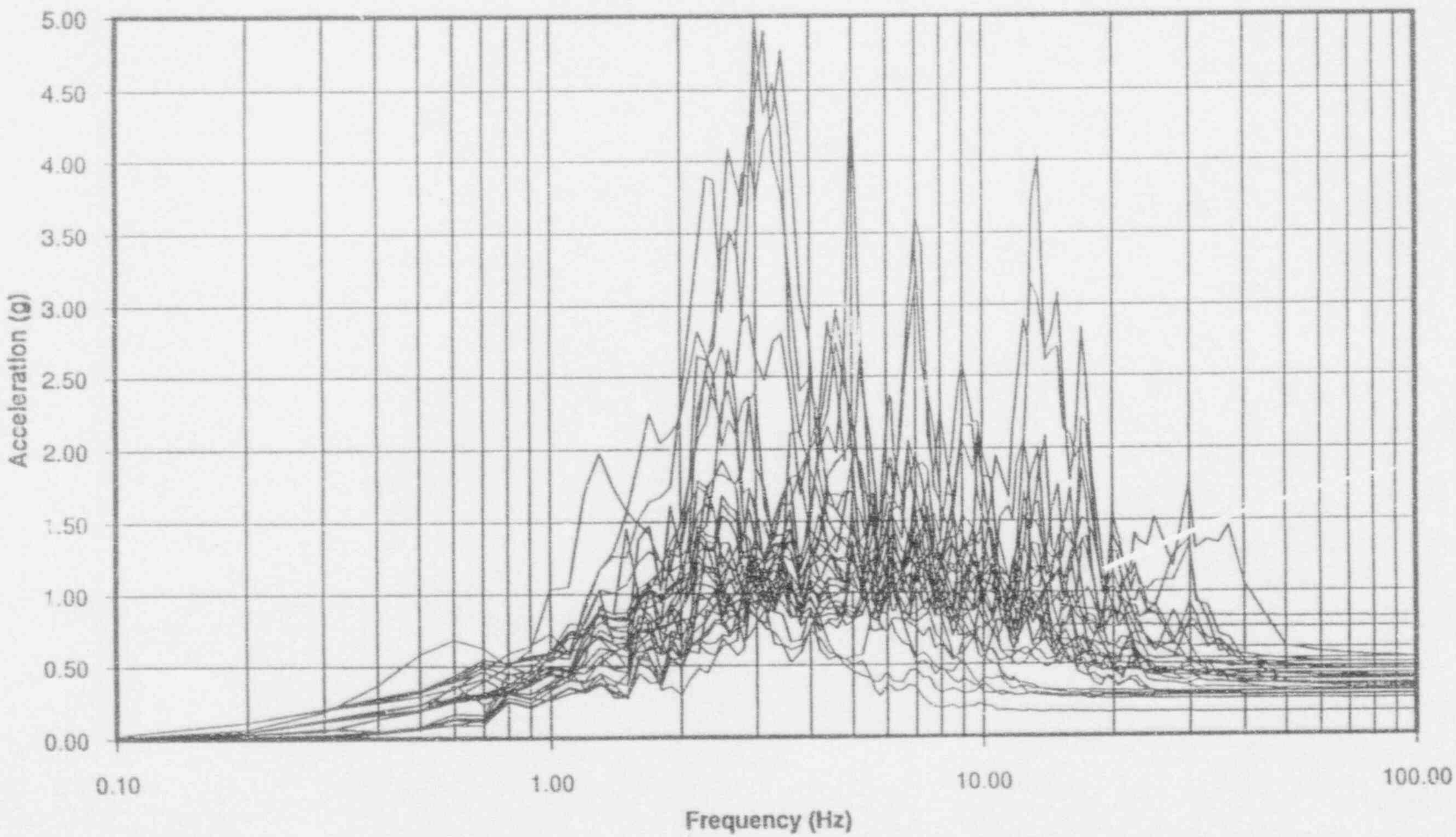

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Figure 3.7C-9

CE System 80+ Response Spectra at Elev. 91.75' of CCW, All Soil Cases, All Motions, Horizontal Model, H2 Motion (N-S), 2% Damping

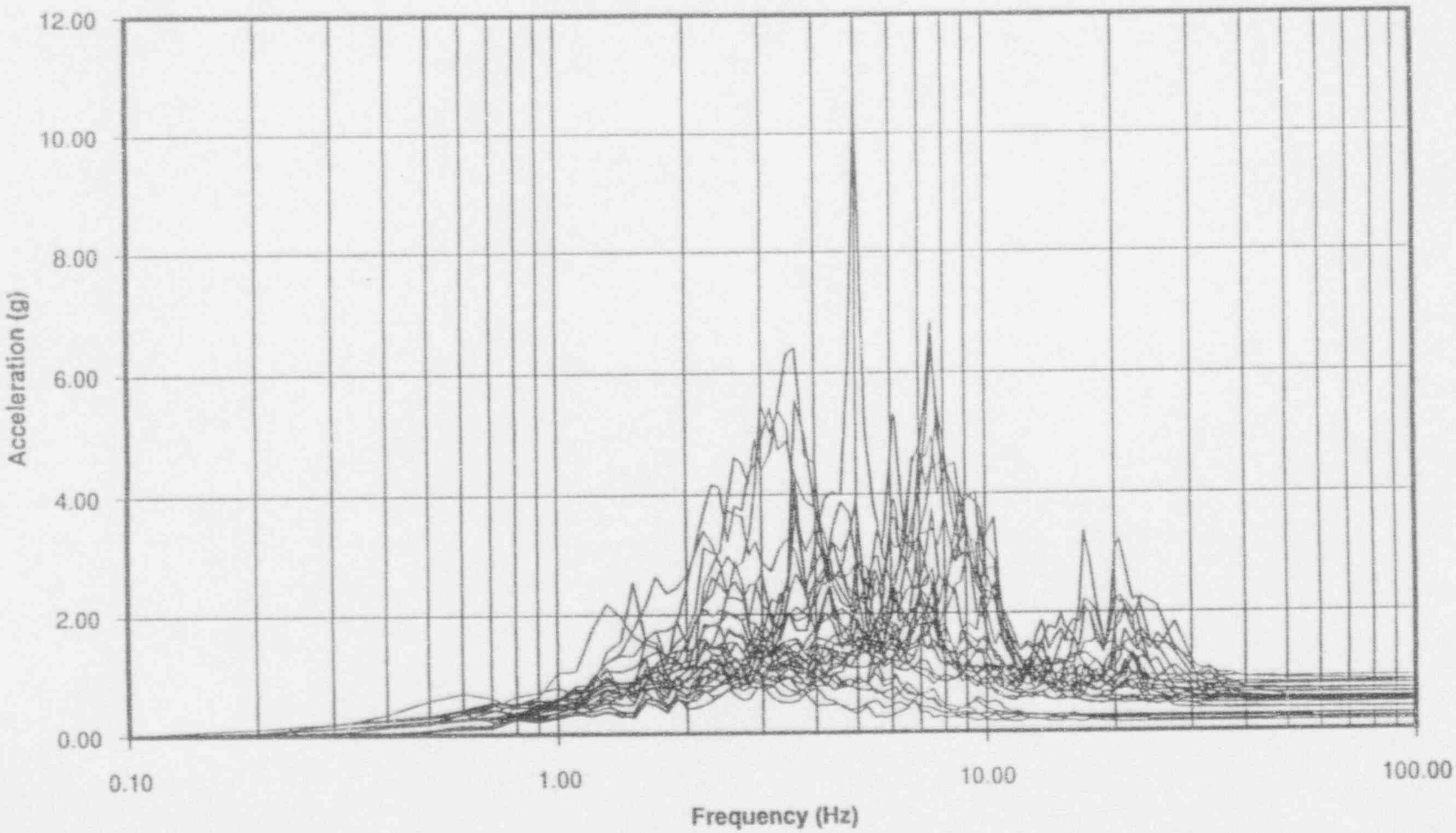

Figure 3.7C-10

~~CE System 80+~~ Response Spectra at Elev. 111.75' of CCW, All Soil Cases, All Motions, Horizontal Model, H2 Motion (N-S), 2% Damping

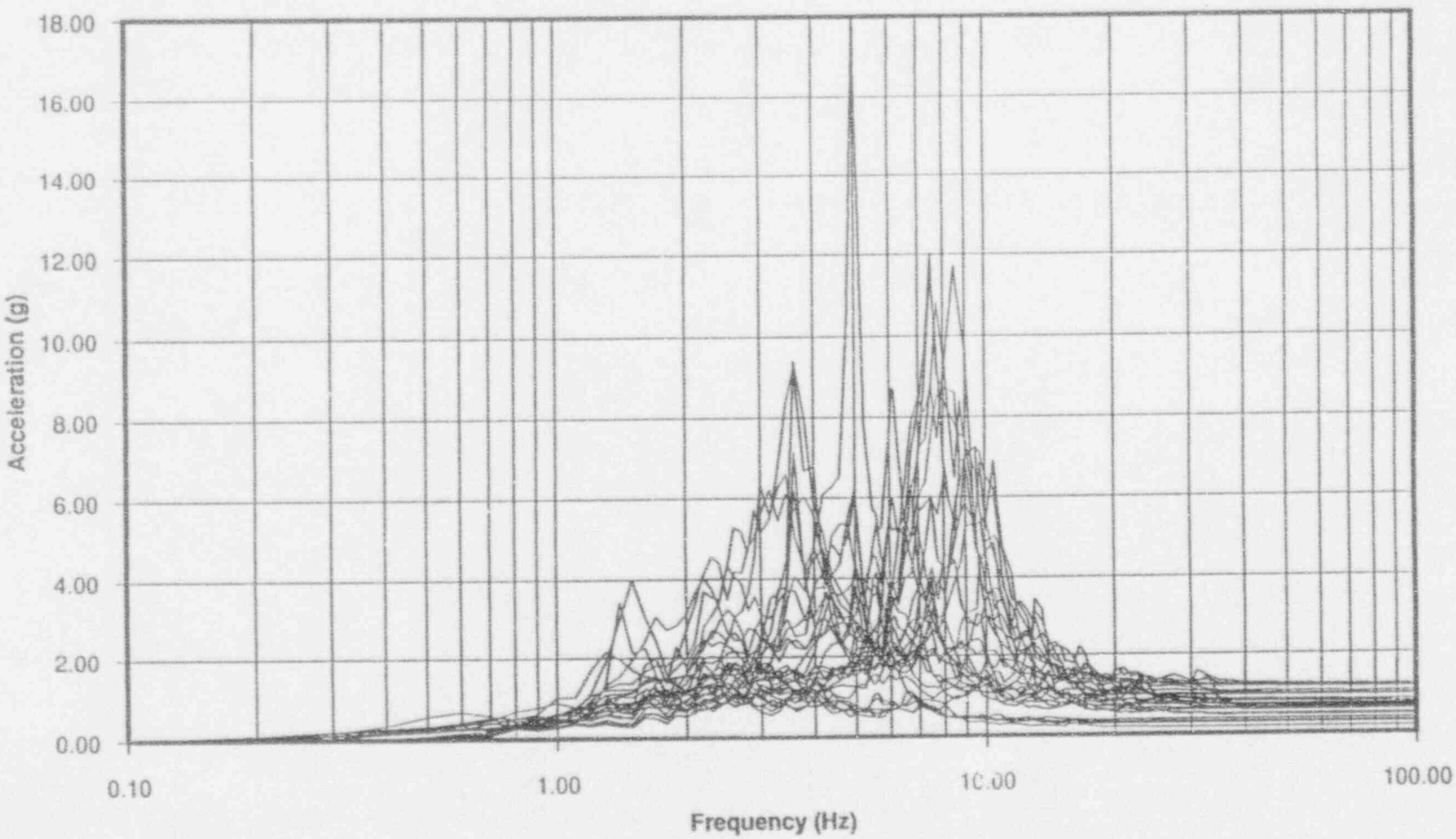

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Figure 3.7C-11

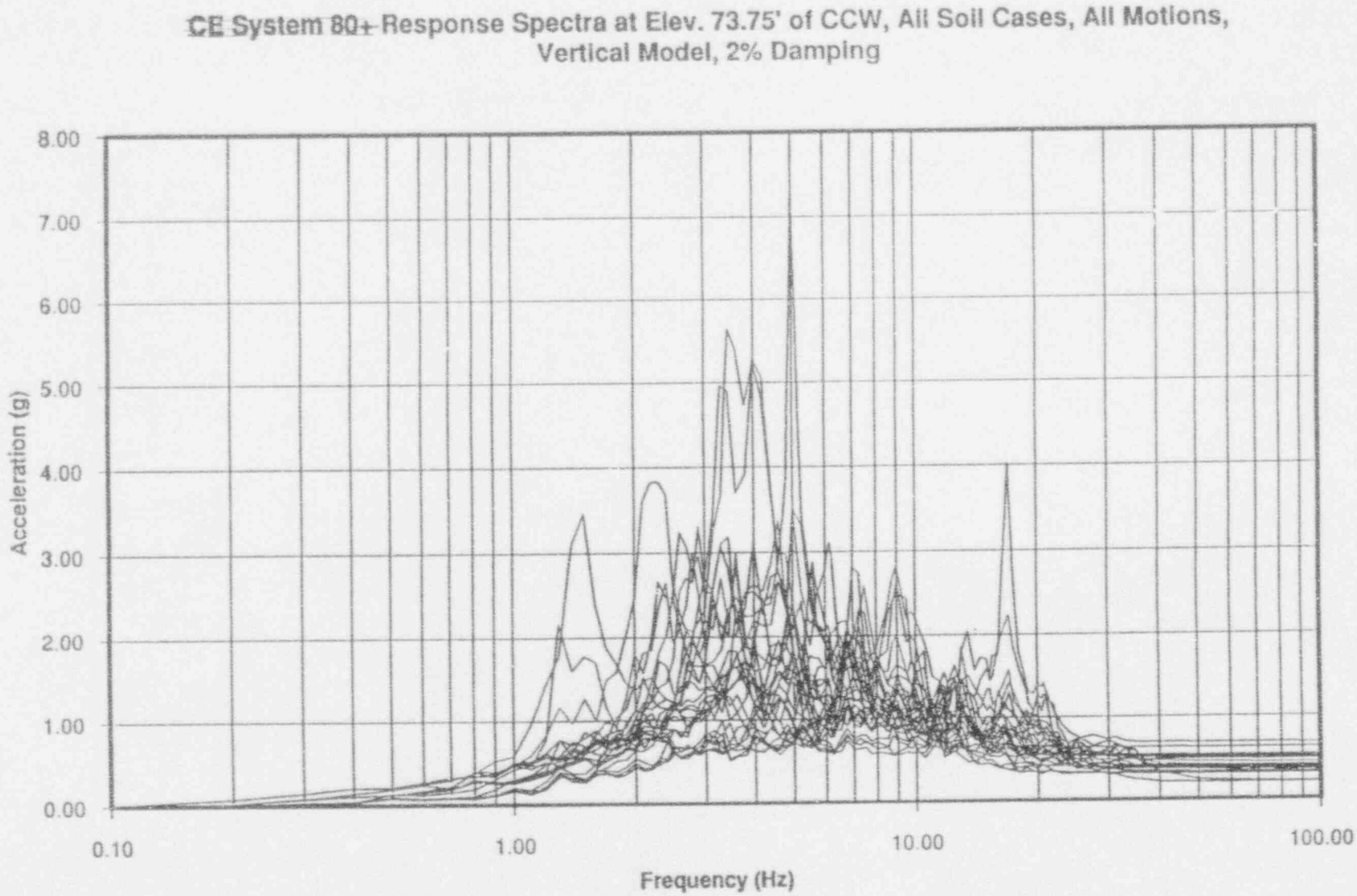

Figure 3.7C-12

~~CE System 80+~~ Response Spectra at Elev. 91.75' of CCW, All Soil Cases, All Motions, Vertical Model, 2% Damping

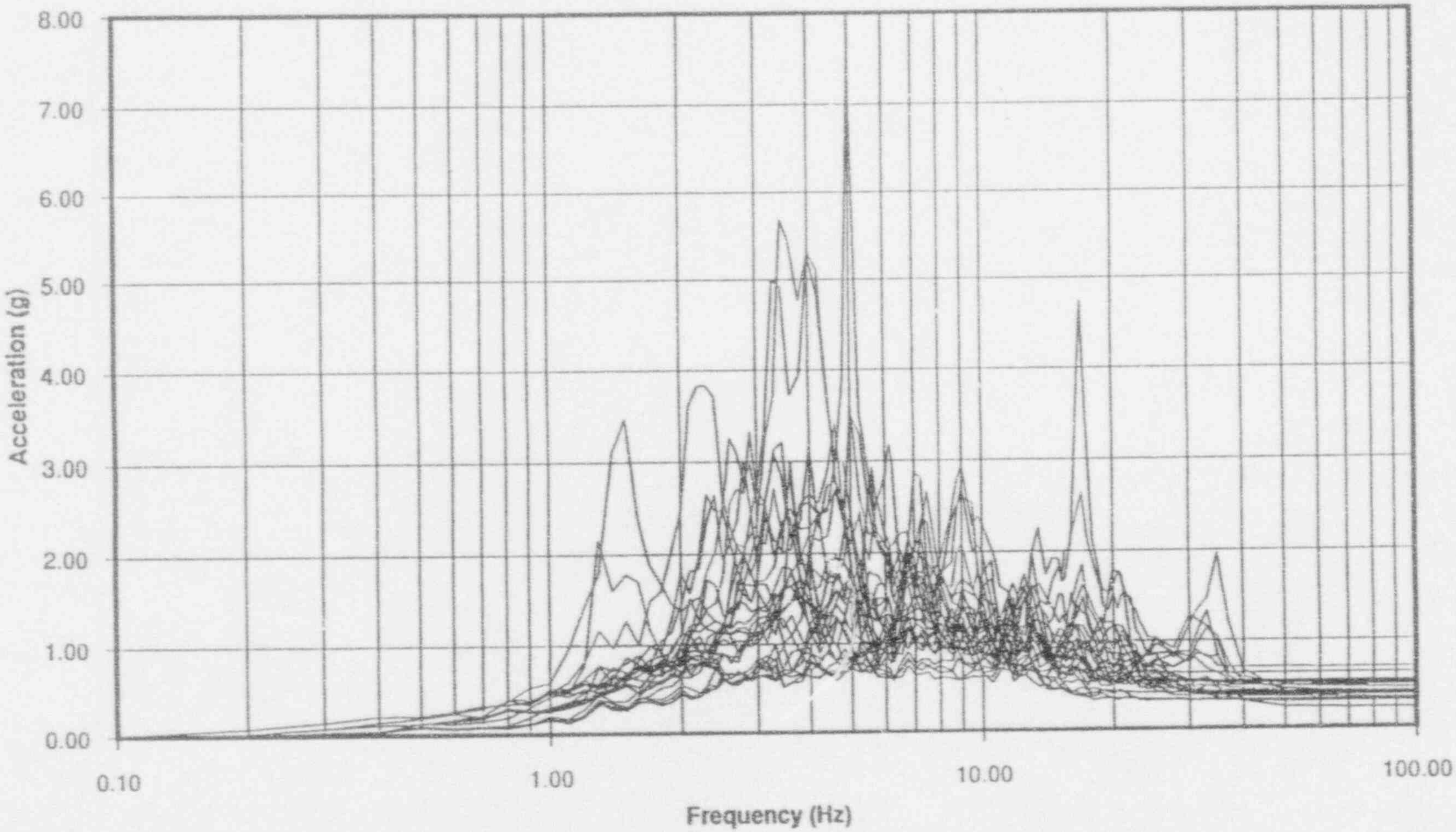

Figure 3.7C-13

~~CE System 80+~~ Response Spectra at Elev. 111.75' of CCW, All Soil Cases, All Motions, Vertical Model, 2% Damping

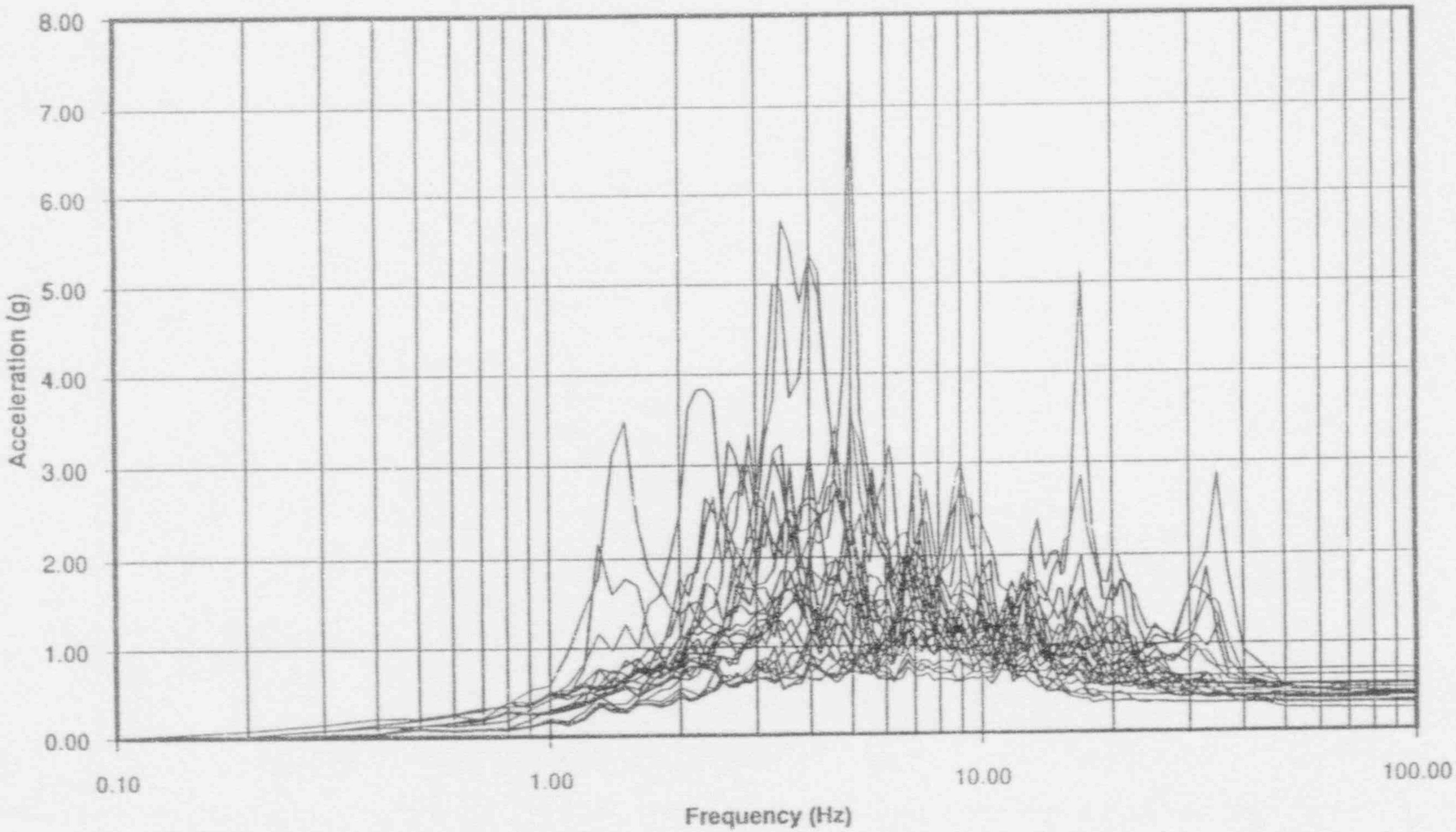

Figure 3.7C-23

~~CE System 80+~~ Response Spectra at Elev. 73.75' of CCW, All Soil Cases, All Motions, Horizontal Model, H2 Motion (N-S), 5% Damping

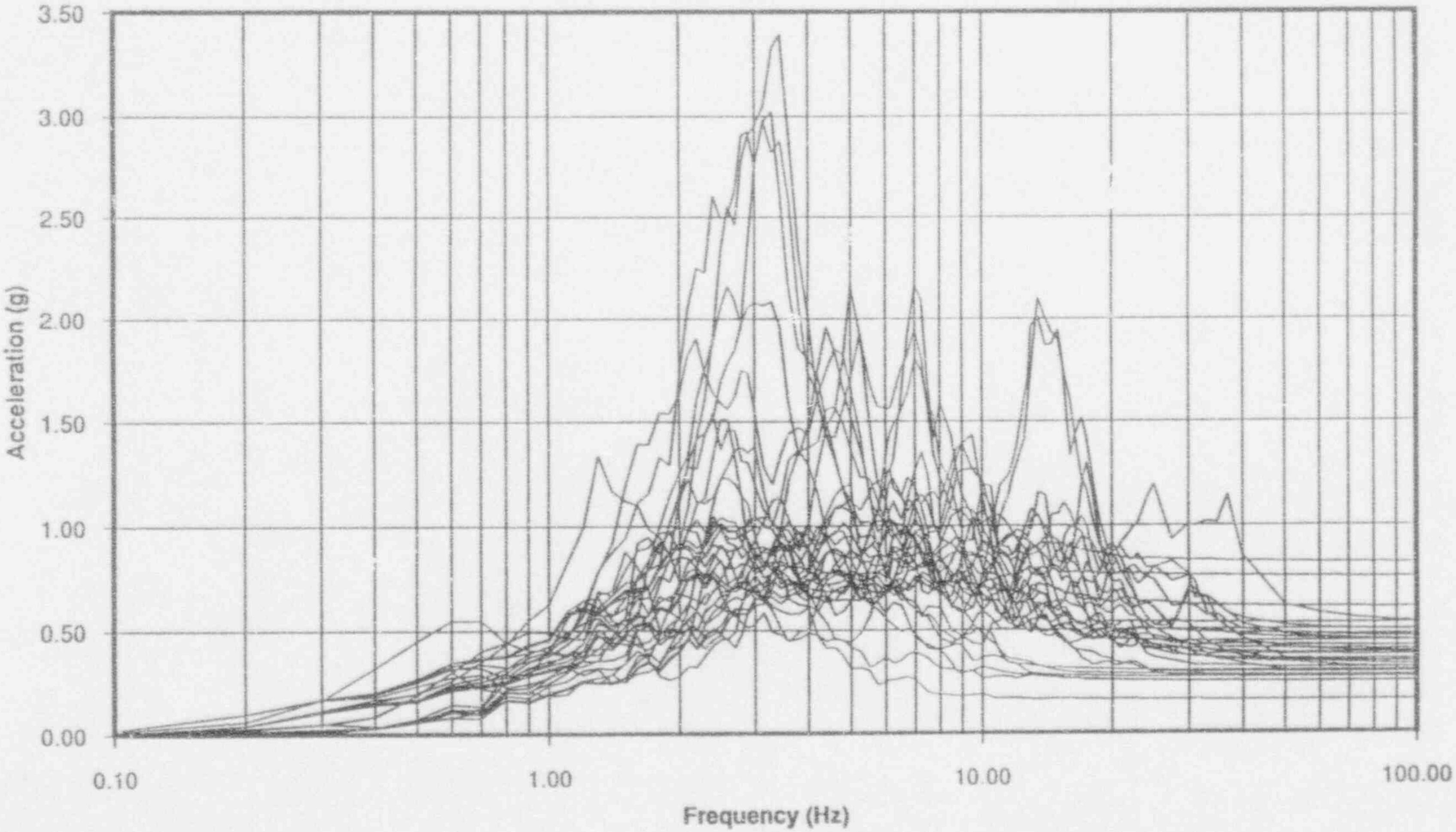

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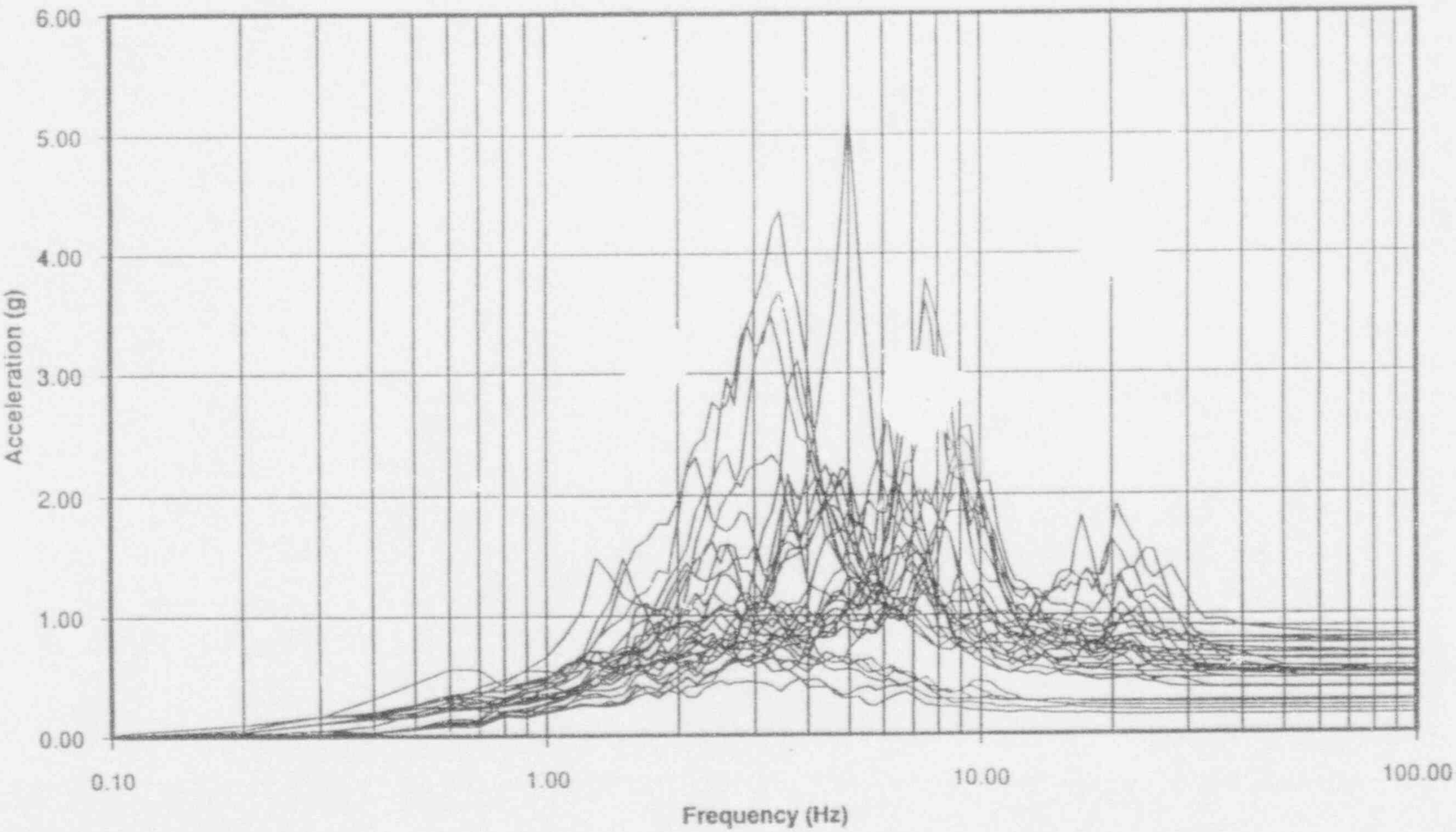
Figure 3.7C-24

CE System 80+ Response Spectra at Elev. 91.75' of CCW, All Soil Cases, All Motions, Horizontal Model, H2 Motion (N-S), 5% Damping



V

Figure 3.7C-25

CE System 80+ Response Spectra at Elev. 111.75' of CCW, All Soil Cases, All Motions, Horizontal Model, H2 Motion (N-S), 5% Damping

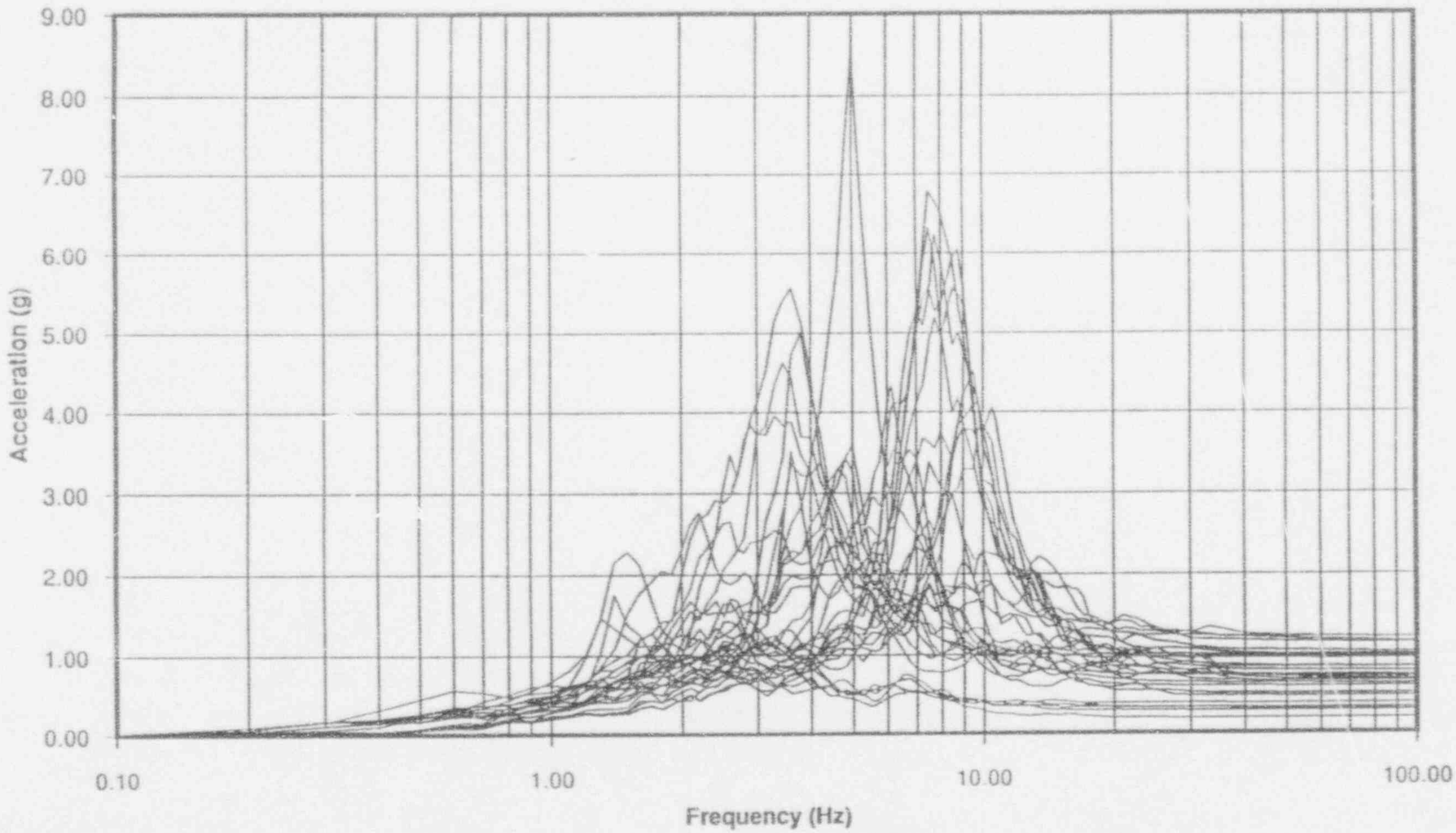


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Figure 3.7C-26

CE System 80+ Response Spectra at Elev. 73.75' of CCW, All Soil Cases, All Motions, Vertical Model, 5% Damping

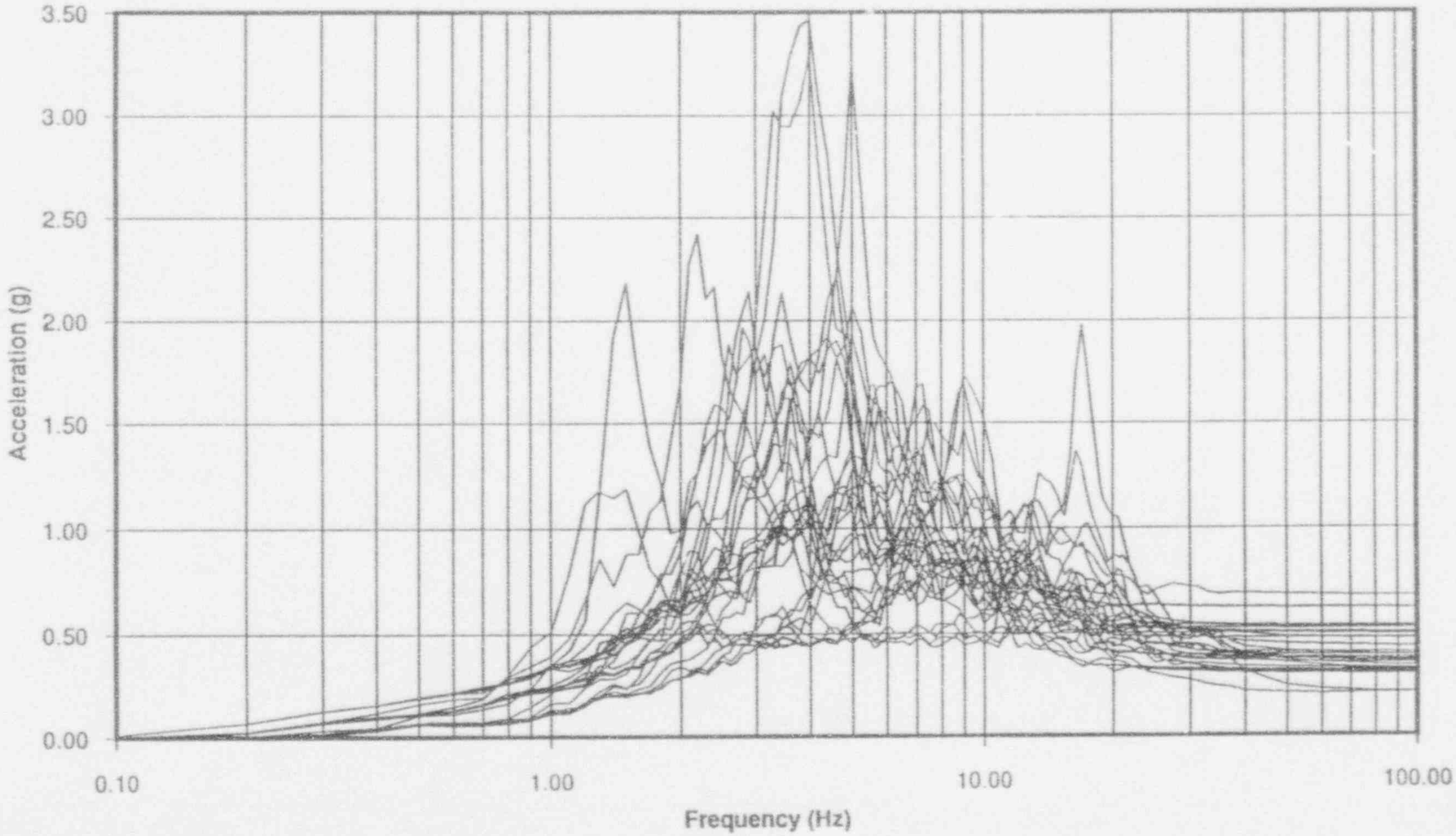

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Figure 3.7B-2?

~~CE System 80+~~ Response Spectra at Elev. 91.75' of CCW, All Soil Cases, All Motions, Vertical Model, 5% Damping

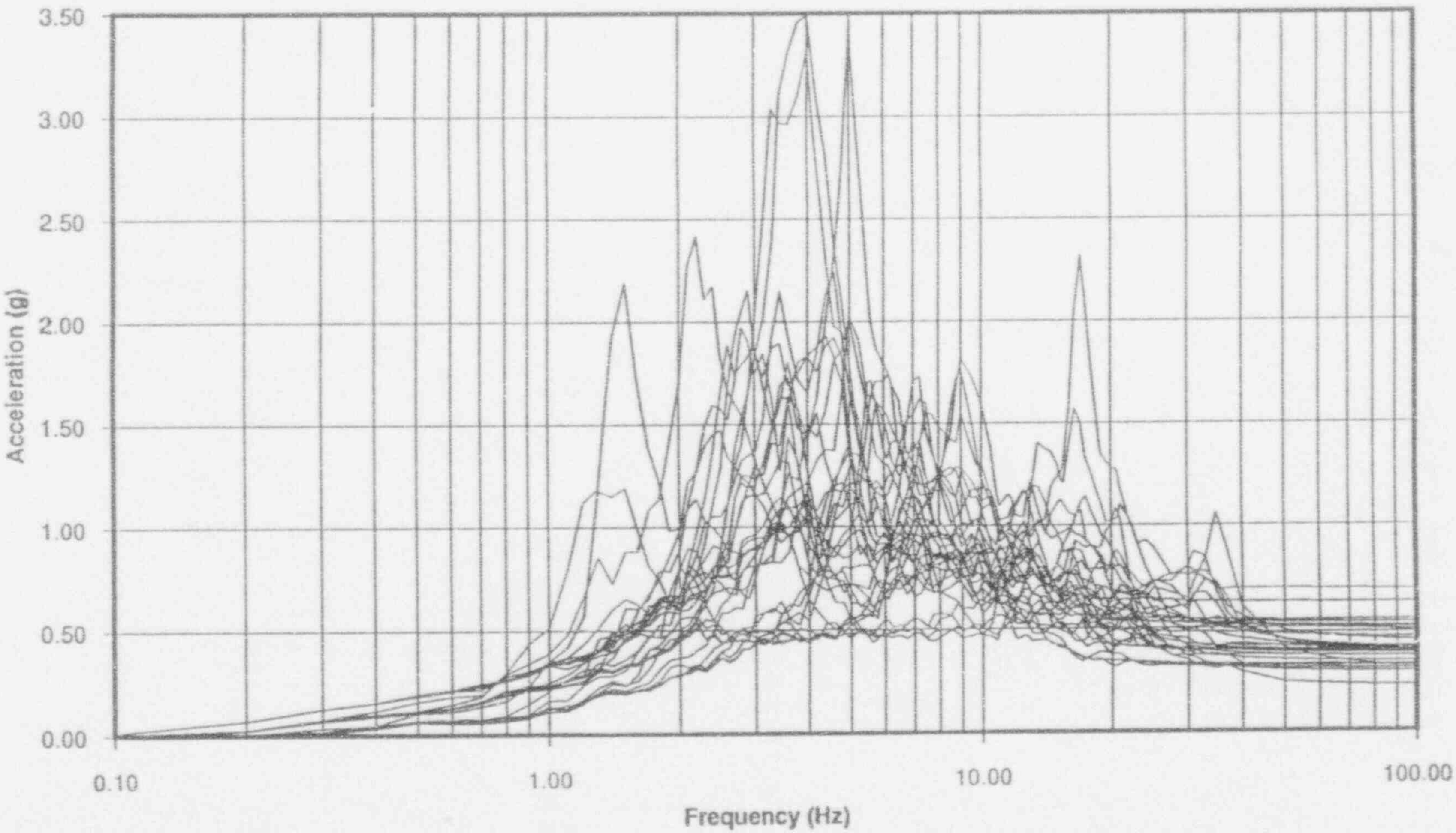

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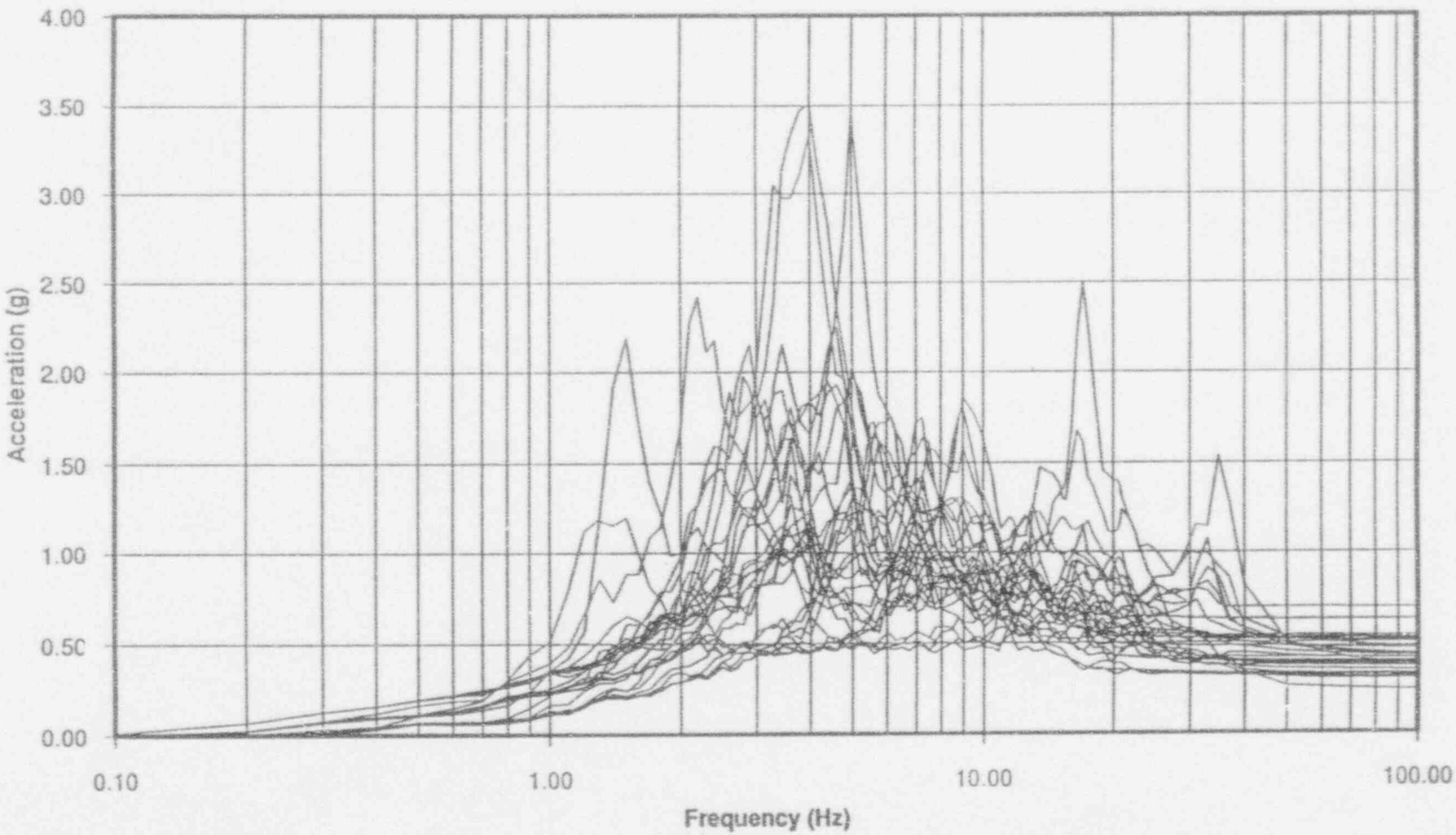
Figure 3.7C-28

CE System 80+ Response Spectra at Elev. 111.75' of CCW, All Soil Cases, All Motions, Vertical Model, 5% Damping



V

Figure 3.7D-42

Broadened ~~CE System 80+~~ Response Spectra at Elev. 91.75' of CCW, HEB All Soil Cases, All Motions, ~~Horizontal Model, H1 Motion (E-W)~~, 5% Damping
E-W Direction

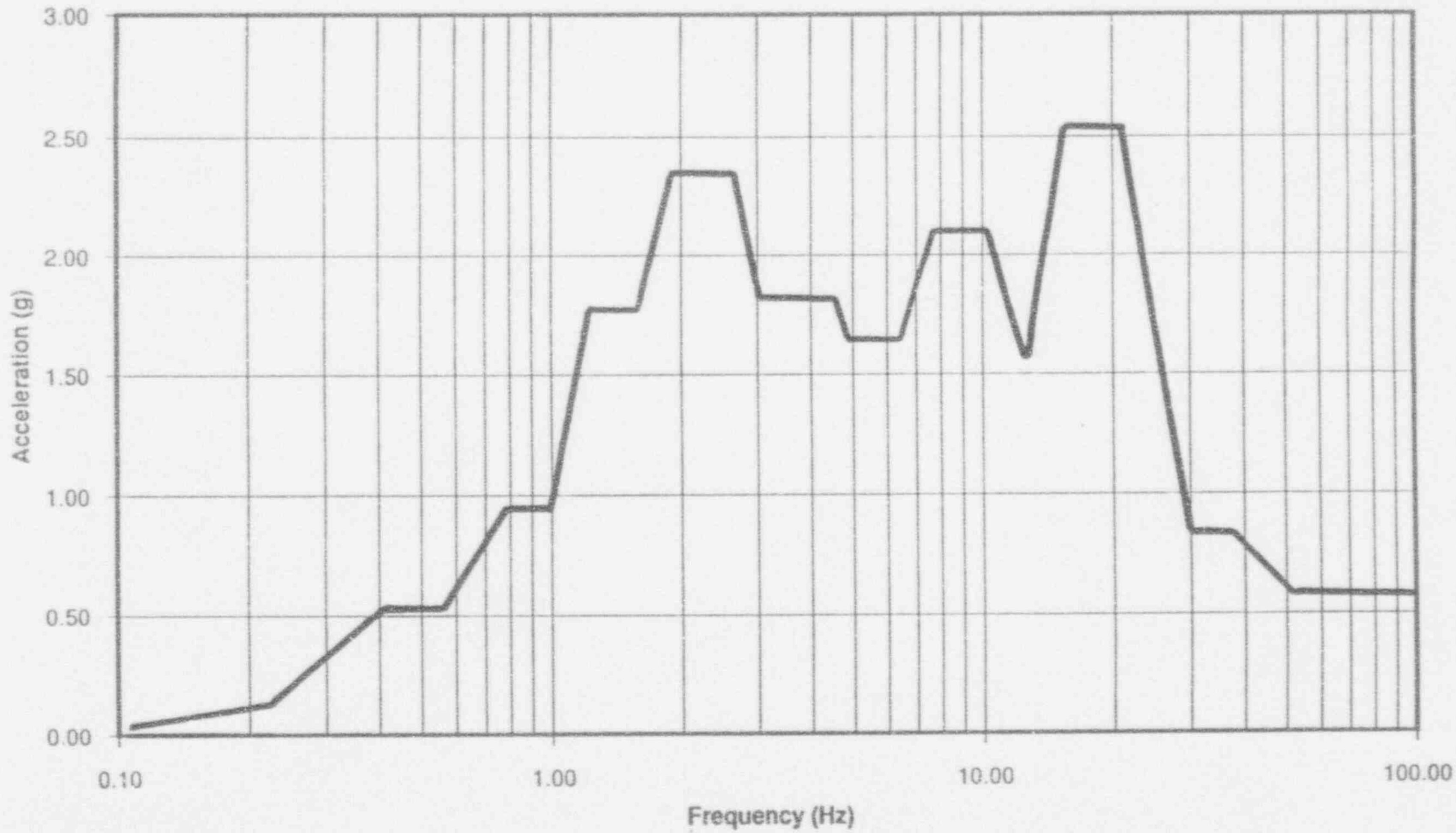


Figure 3.7D-43

Broadened ~~CE System 80+~~ Response Spectrum at Elev. 91.75' of CCW HEB, All Soil Cases, All Motions, ~~Horizontal Model, H2 Motion (N-S)~~, 5% Damping
N-S Direction

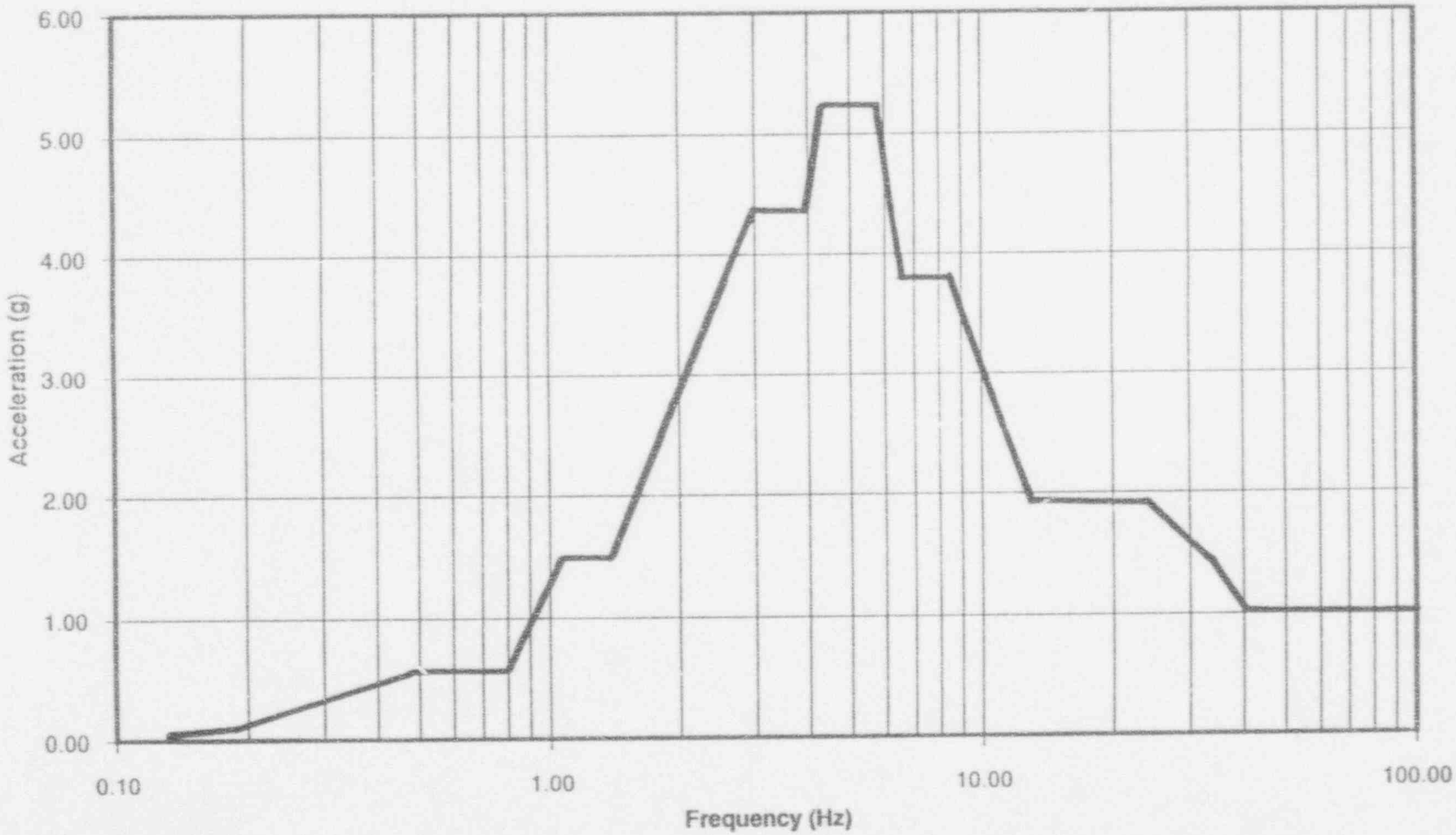


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Figure 3.7D-44

Broadened ~~CE System 80+~~ Response Spectra at Elev. 91.75' of CCW HEB, All Soil Cases, All Motions, Vertical ~~Model~~ Direction, 5% Damping

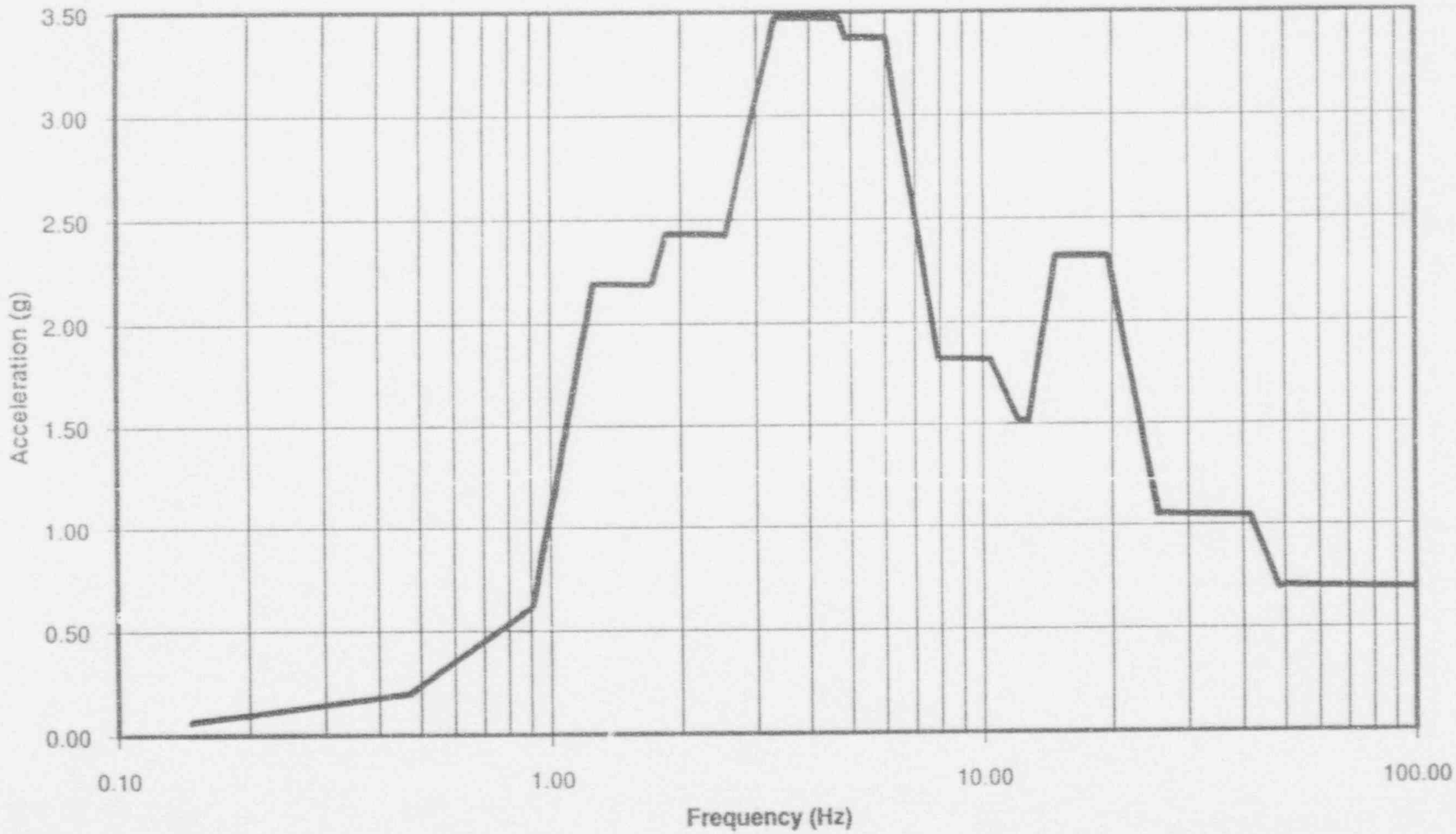


Figure 3.7D-45

Broadened ~~CE System 80+~~ Response Spectr~~a~~um at Elev. 78.25' of DFSS, All Soil Cases, All Motions, ~~Horizontal Model, H1 Motion (E-W)~~, 5% Damping

E-W Direction

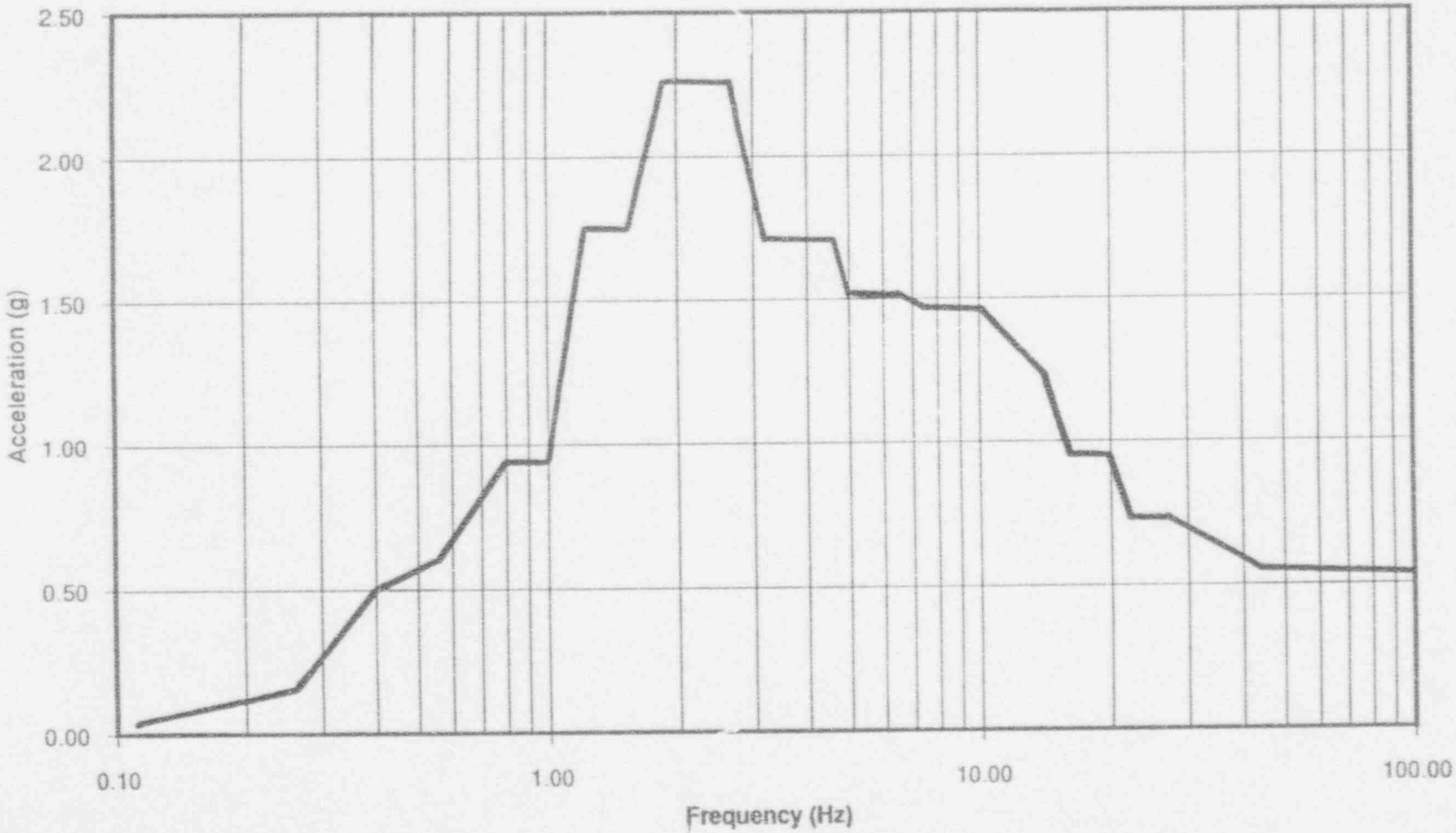


Figure 3.7D-46

Broadened
~~CE System 80+~~ Response Spectra at Elev. 78.25' of DFSS, All Soil Cases, All Motions,
~~Horizontal Model, H2 Motion (N-S)~~, 5% Damping
N-S Direction

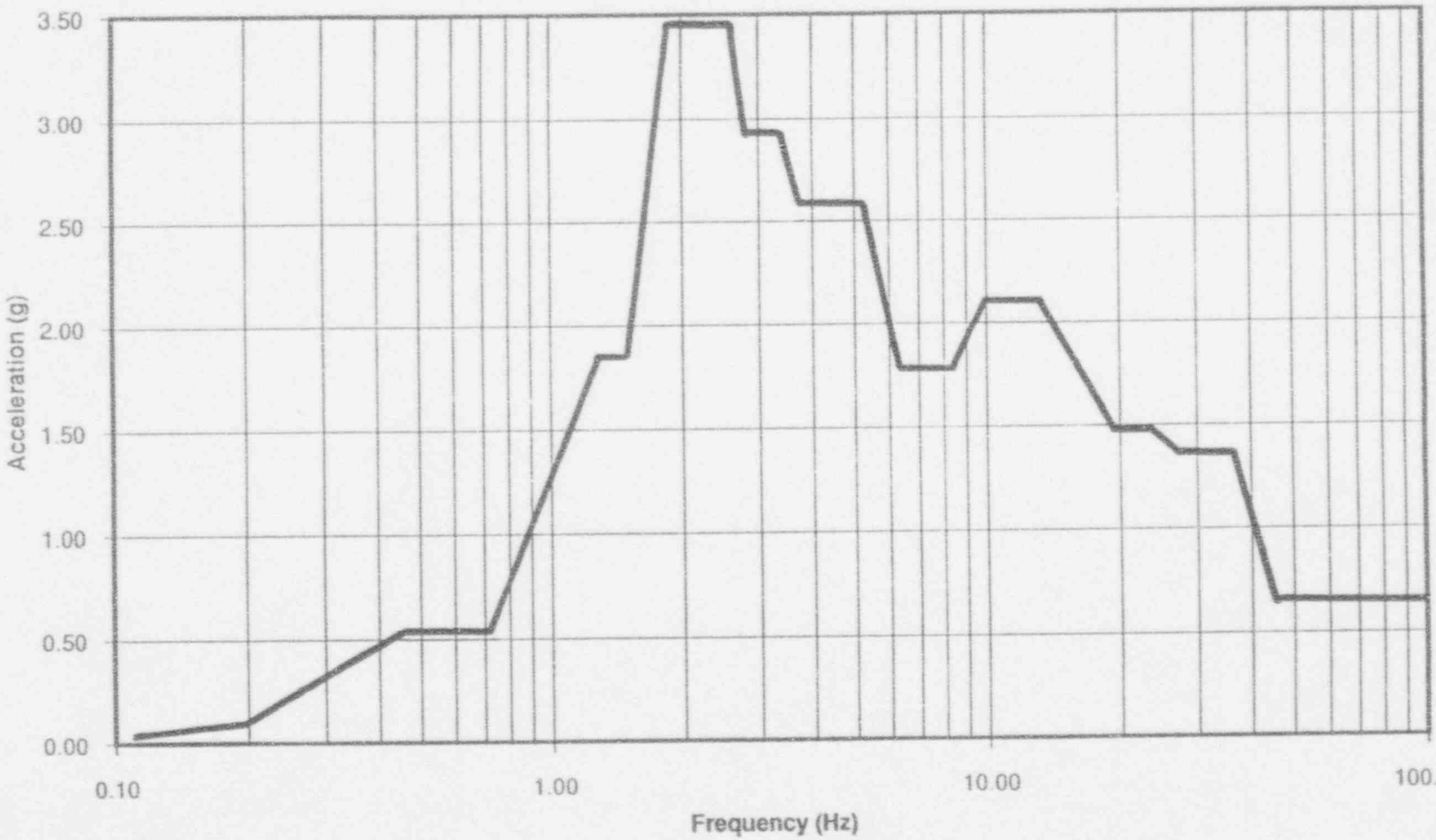
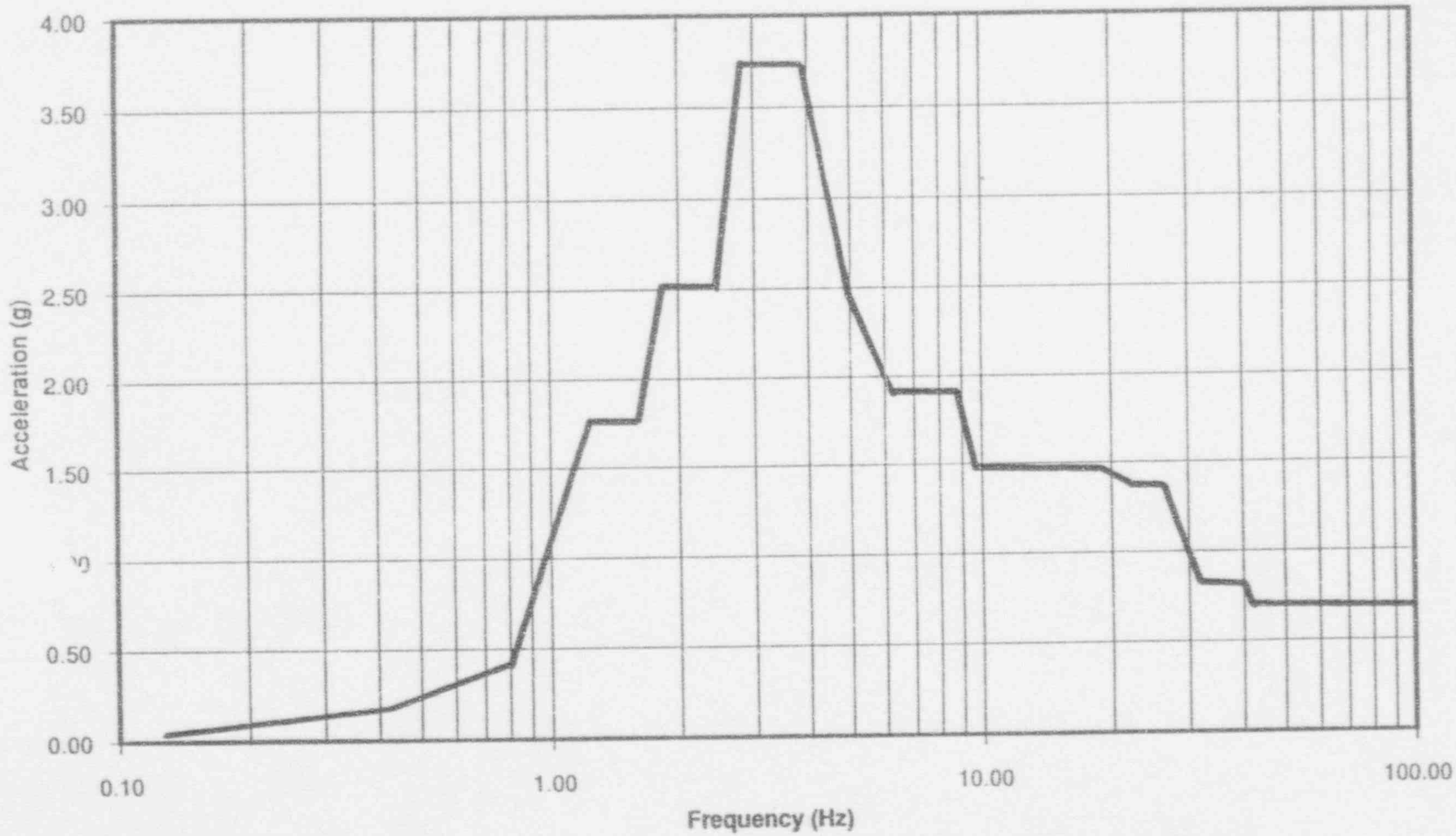


Figure 3.7D-47

Broadened ~~CE System 80+~~ Response Spectra um at Elev. 78.25' of DFSS, All Soil Cases, All Motions, Vertical ~~Model~~ Direction, 5% Damping



The containment vessel is analyzed to determine the stress levels and stability factors of safety resulting from the application of specified loads. The vessel is analyzed using thin shell finite element methodology. The ANSYS computer code (Reference 2) is used to generate the geometry of the shell, determine stress levels in the shell, and evaluate shell stability.

3.8.2.4.1 Description of Finite Element Models

3.8.2.4.1.1 3-D Finite Element Model

A pictorial presentation of the containment vessel 3-D finite element model is given in Figure 3.8-3. An eight node isoparametric thin shell element is used. Fixed boundary conditions are applied in the model at the 90'+3" elevation.

The weight of the personnel airlocks and the equipment hatch penetrations is included in the model by increasing the density of the shell in the region of the penetration. Live load is included in the weight of the penetrations. The penetrations themselves are not modelled explicitly. The thickness of the shell in the region of the personnel airlocks and the equipment hatch is increased using the area replacement rules in the ASME Code. The containment spray mass is included in the upper region of the model by distributing additional mass at the appropriate locations in the dome. The mass of the piping and the electrical penetrations in the lower region of the sphere is accounted for by increasing the density of the shell elements in that region. The stiffness of the compressible material at the base of the containment vessel is modeled as a two-directional spring.

Although the transition region of the SCV is 2 inches thick, the 3-D finite element model has a uniform shell thickness of 1-3/4 inches. The additional 1/4 inch of material in the transition region is for corrosion allowance only and credit for this additional thickness is not included in the 3-D analysis. The axisymmetric model described in Section 3.8.2.4.1.2 is used to evaluate the effects of the change in material thickness in the transition region.

3.8.2.4.1.2 Axisymmetric Finite Element Model

The containment with vessel is modelled with thin shell axisymmetric finite elements. The model is fixed at the base, elevation 90'+3"~~, and a~~ two-directional spring elements ~~is attached at the concrete surface elevation, 91'+9",~~ to represent the compressible material at the base of the containment vessel. The meridian modeled is the one corresponding to the equipment hatch since it has the

The primary membrane stress evaluation for Service Level A is the same as the Design Condition.

When evaluating secondary stress effects, the reduced load combination is:
$D + L + T_a + P_a$

Service Level C:

Pipe reactions R_a and R_o are eliminated as described in the Design combination.

The stresses resulting from the operating pressure loads, P_o, are enveloped by the accident pressure loads and therefore are not analyzed separately.

The T_a and T_o loads are not included in the combination because thermal loads are considered as secondary stresses as described in the Design combination. The ASME code does not require an analysis of secondary stresses for Service Level C.

The reduced Service Level C loads are the same as the reduced Service Level D loads. The ASME Service Level D allowable stresses are lower than the Service Level C allowable stresses; therefore, the analysis is performed for the reduced Service Level D loading combination and compared with the lower allowable stresses of Service Level D.

Service Level D:

Pipe reactions, operating loads, and thermal loads are eliminated as described in the Service Level C combination.

The pipe rupture loads, Y_r, are eliminated in the design by the use of rupture restraints and guard pipes in the System 80+ design. The jet impingement loads, Y_j, are eliminated by the use of guard pipes and, where necessary, jet impingement protection devices. The containment shell is protected from the missile loads, Y_m, by the crane wall inside the containment vessel and the head area cable tray system.

The reduced load combination is:
$D + L + P_a + E'$

D. Construction Loads

All loads in the combination given in Table 3.8-2 are applicable to the System 80+ design.

The Service Level C and D stability analyses are completed for two types of imperfections:

1) A full sine wave with a half-wavelength = 8 feet and a peak to peak amplitude of 1.75 inches.

2) A half sine wave with a half-wavelength = 16 feet and a peak amplitude of 1.75 inches.

The resulting Service Level C stability safety factors for these two types of imperfections are 2.70 and 2.74, respectively.

F. Ultimate Load Considerations $(D + L + P_u)$

The Ultimate Capacity is determined using an elastic analysis with the axisymmetric model. All loads are applied simultaneously in a static manner. The dead and live load is applied as an increase in the density in the appropriate regions. The internal pressure load, which is applied to the inside face of each element, is increased until the maximum stress intensity reaches the Service Level C allowable membrane stress intensity for the given temperature. The ASME Service Level C allowable stress intensity value is the nominal yield stress value for the temperature given. Temperature values of 150°F, 290°F (Design Basis Accident Temperature), 350°F, and 450°F are evaluated. The material properties associated with the temperatures are used. The internal pressure value which results in a maximum stress intensity equal to the Service Level C allowable membrane stress intensity is the ultimate pressure capacity, P_u. The results are summarized in Table 3.8-3D.

G. Combustible Gas Load Considerations $(D + L + P_g + P_a)$

space

The Combustible Gas Loading is evaluated using an elasticanalysis with the axisymmetric model. The dead and live load is applied as an increase in the density in the appropriate regions. The peak pressure from hydrogen combustion and the design basis pressure is added together and applied as an internal pressure to the inside face of each element. All loads are applied simultaneously in a static manner to determine the maximum membrane stress intensity. The results are summarized in Table 3.8-3A. V

H. Containment Overturning and Sliding $(D + L + E')$

The containment is analyzed for sliding and overturning of the interior structures against the steel containment and the interior structures and steel containment against the lower concrete dish structure outside of containment. The interior structures and the steel containment are modelled

Deviations from the design are acceptable provided the following acceptance criteria are met:

1. An evaluation is performed (depending on the extent of the deviations, the evaluation may range from the documenting of an engineering judgement to performance of a revised analysis and design), and

2. The structural design meets the requirements specified in Section 3.8.2.

The COL applicant will prepare an as-built structural analysis report for the steel containment vessel.

3.8.2.5.1 Welding and Weld Acceptance Criteria

Welding activities shall be in accordance with the requirements of Section III, Subsection NE of the ASME Code.

INSERT (A)

3.8.2.6 <u>Materials, Quality Control, and Special Construction Techniques</u>

3.8.2.6.1 Materials

The containment vessel materials are in accordance with Article NE-2000 of Subsection NE, "Class MC Components," of the ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Power Plant Components."

The containment plate material is ASME SA537 Class 2. This material is exempt from post-weld heat treatment requirements when plate thickness is less than or equal to 1.75 inches in accordance with Table NE-4622.7(b)-1 of the ASME Boiler and Pressure Vessel Code, Section III. When plate thickness exceeds 1.75 inches, post weld heat treatment shall be performed. The material will be impact tested in accordance with Article NE-2300 of Section III of the ASME Code.

Fabrication and erection of the containment vessel are in accordance with Article NE-4000 of Section III of the ASME Code. This includes welding procedures, procedure and operator performance qualifications, post weld heat treatment and tolerances.

Nondestructive examination of welds and materials is in accordance with Article NE-5000 of Section III of the ASME Code.

3.8.2.6.2 Quality Control

The general provisions of the overall Quality Assurance program are outlined in Chapter 17. These are supplemented by the special provisions of the ASME Code for quality control as applicable to Class MC Components. The containment vessel is

INSERT A (to Section 3.8.2.5.1)

Radiographic examinations will be accepted by the COL applicant's nondestructive examination (NDE) Level III examiner prior to final acceptance.

Confirmation that facility welding activities are in compliance with the certified design commitments shall include verifications of the following by individuals other than those who performed the activity:

1. Facility welding specifications and procedures meet the applicable ASME Code requrements,

2. Facility welding activities are performed in accordance with the applicable ASME Code requirements,

3. Welding activities related records are prepared, evaluated and maintained in accordance with the ASME requirements,

4. Welding processes used to weld dissimilar base metal and welding filler metal combinations are compatible for the intended applications,

5. The facility has established procedures for qualifications of welders and welding operators in accordance with the applicable ASME Code requirements,

6. Approved procedures are available and are used for pre-heating and post-heating of welds, and those procedures meet the applicable requirements of the ASME Code,

7. Completed welds are examined in accordance with the applicable examination method required by the ASME Code.

The concrete is sealed to preclude moisture. A visual inspection of coatings is performed.

Visual inspections of containment base metal and welds are performed in accordance with ASME Section XI, Subsection IWE and 10CFR50 Appendix J. These are formal inservice inspection requirements. The portions of containment embedded in the concrete are exempt from these inspection requirements while the welds around the embedded penetrations are required to be inspected.

Collection of moisture in the transition region is prevented by use of sloped floors and drains.

The compressible material which is placed in the transition region between the steel and concrete is removable. Once removed the material and SCV ~~can be~~ is inspected. |V

No equipment or ductwork is located such that it inhibits a visual inspection at the steel concrete interface for corrosion.

For further precautionary measures and conservatism, the SCV is 2 inch in thickness in the transition region. This thickness is beyond design requirements and allows for a corrosion allowance of approximately 4 mils per year over a 60 year life. With an inspection program and maintenance of the coatings, corrosion is minimized in this region.

3.8.2.7 Testing and In-service Surveillance Requirements

The containment vessel, personnel airlocks and equipment hatch are inspected and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Subsection NE. Penetrations are pressure tested as required for Subsection NC of the ASME Code.

Periodic leakage rate tests of the containment are conducted in accordance with 10CFR50, Appendix J to verify leak tightness and integrity. These tests and other in-service inspection requirements are described in Section 6.2. Periodic in-service inspections are conducted in accordance with the ASME Boiler and Pressure Vessel Code, Section XI, Subsection IWE.

3.8.3 CONCRETE AND STRUCTURAL STEEL INTERNAL STRUCTURES

3.8.3.1 Description of the Internal Structures

The internal structure is a group of reinforced concrete structures that enclose the reactor vessel and primary system. The internal structure provides biological shielding for the containment interior. The internal structure concrete base rests inside the lower portion of the containment vessel sphere. A

1.6 instead of 1.7 in load combination 11.

4. The following note is added to Section Q1.5.8:

"For constrained (rotation and/or displacement) members supporting safety related structures, systems, or components, the stresses under load combinations 9, 10, and 11 should be limited to those allowed in Table Q1.5.7.1 as modified by provision 3 above. Ductility factors of Table Q1.5.8.1 (or provision 5 below) should not be used in these cases."

5. For ductility factors 'μ' in Sections Q1.5.7.2 and Q1.5.8, are substituted provisions of Appendix A, II.2 of SRP Section 3.5.3 in lieu of Table Q1.5.8.1.

6. In load combination 9 of Section Q2.1, the load factor applied to load P is 1.5/1.1 = 1.37, instead of 1.25.

7. Sections Q1.24 and Q1.25.10 is supplemented with the following requirements regarding painting of structural steel:

   a) Shop painting shall be in accordance with Section M3 of Reference 17.

   b) All exposed areas after installation shall be field painted (or coated) in accordance with the applicable portion of Section M3 of Reference 17.

   c) The quality assurance requirements for painting (or coating) of structural steel shall be in accordance with Reference 18 as endorsed by Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water Cooled Nuclear Power Plants".

Welding activities associated with Seismic Category I structural steel components and their connections shall be accomplished in accordance with written procedures and shall meet the requirements of ~~ANSI/AISC N690 Section Q1.17.~~ AWS D1.1 (REFERENCE 25). The visual acceptance criteria shall be as defined in NCIG-01 (Reference 24). IV

3.8.4.5.3 Concrete and Steel Structures

In addition to satisfying the load combinations for structural adequacy against the design loadings, the load combinations to ensure safety factors against overturning, sliding, and flotation are checked to ensure overall stability of Seismic Category I structures. The following events are checked as a minimum:

A. The overturning about the toe of the foundation supported on soil.

B. The foundation sliding on soil.

C. Floating of the foundation base mat.

D. The containment vessel slipping in the lower concrete support dish.

E. The containment vessel overturning about the edge of the lower concrete support dish.

F. The interior structure concrete slipping inside the containment vessel.

New Section

The safety factors which must be satisfied during any of these events are shown in ~~Table 3.8-5~~. Appendix 3.8A, Section 5.2.4.

No increase in allowable stresses under service load conditions due to normal or severe load combinations is permitted due to wind loadings as identified in NUREG-0800, NRC Standard Review Plan, Section 3.8.4, Part II.5.

3.8.~~4~~5.4 Structural Analysis Report

A structural analysis report will be prepared for Seismic Category I structures. This report will document that the structures meet the ~~requirements~~ acceptance criteria specified in Section 3.8 and design changes and identified construction deviations, which could potentially affect the structural capability of the structure, have been incorporated into the structural analysis, consistent with the methods and procedures of Section 3.8. The following records will be reviewed, as applicable:

1. Construction records stating material properties for concrete, reinforcing steel, and structural steel

2. As-built structure dimensions and arrangements, including spatial separation of buildings

4 ~~3~~. Design documents for the structure

Deviations from the design are acceptable provided the following acceptance criteria are met:

1. An evaluation consistent with the methods and procedures of Sections 3.7 and 3.8 is performed (depending on the extent of the deviations, the evaluation may range from the documenting of an engineering judgement to performance of a revised analysis and design), and

2. The structural design meets the ~~requirements~~ acceptance criteria specified in Section 3.8, and

3. The seismic floor response spectra of the as-built structure does not exceed the design basis floor response spectra by more than 10%.

3. As built load requirements including those for subcompartment global pressure/temperature effects and for anchor and pipe whip restraints

include in new Sect. 3.8.4.5.4

The structural analysis report will summarize the results of the reviews, evaluations, and corrective actions, as applicable, and conclude that the as-built structure is in accordance with the design.

Welding activities associated with the Refueling Cavity and Spent Fuel Pool liners shall be accomplished in accordance with the requirements of the American Welding Society (AWS) Structural Welding Code, D1.1 (Reference 25). The welded seams of the liner plates shall be spot radiographed where accessible, liquid penetrant and vacuum box examined after fabrication to ensure the liners do not leak. The acceptance criteria shall meet the acceptance criteria stated in Article NE-5200, Section III, Division I of the ASME Code.

3.8.4.5.4

3.8.4.6 Material, Quality Control, and Special Construction Techniques

The Category I structures are poured-in-place reinforced concrete structures. The major materials that will be used in the construction are concrete, reinforcing bars and structural steel. A brief description of these materials is given below.

3.8.4.6.1 Material

3.8.4.6.1.1 Concrete

The basic ingredients of concrete are cement, fine aggregates, coarse aggregates, and mixing water. Admixtures will be used if needed.

Cement will be Type I or Type II conforming to "Standard Specification for Portland Cement," ASTM C150. For special circumstances, other approved cements will be used.

Aggregates will conform to "Standard Specification for Concrete Aggregate," ASTM C33.

Water used in mixing concrete will be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials or other substances that may be deleterious to concrete or steel. A comparison of the proposed mixing water properties will be made with distilled water by performing the following tests:

A. Soundness, in accordance with "Standard Test Method for Autoclave Expansion of Portland Cement," ASTM C151. The results obtained for the proposed mixing water will not exceed those obtained for distilled water by more than ten percent.

3.8.4.6.1.2 Reinforcing Steel

Reinforcing steel will consist of deformed reinforcing bars conforming to "Standard Specification for Deformed and Plain Billet - Steel Bars for Concrete Reinforcement," ASTM A615, Grade 60 or "Specifications for Low-alloy Steel Deformed Bars for Concrete Reinforcing," ASTM A706, Grade 60. The fabrication of reinforcing bars, including fabrication tolerances, will be in accordance with CRSI "Manual of Standard Practice" MSP-1. The placing of reinforcing bars, including spacing of bars, concrete protection of reinforcement, splicing of bars and field tolerances will be in accordance with ACI 349. Epoxy coated reinforcing steel is used for areas where a corrosive environment is encountered.

3.8.4.6.1.3 Structural Steel

The structural steel will essentially consist of low carbon steel shapes, plates and bars conforming to "Standard Specification for Structural Steel," ASTM A36. Other structural steels listed in ANSI/AISC N690 may also be used.

Fabrication and erection of structural steel in Seismic Category I structures will be in accordance with the requirements of ANSI/AISC N690. The structural connections will be either welded or bolted. Welding activities associated with Seismic Category I structural steel components and their connections shall meet the requirements in Section 3.8.4.5.2. ¶All bolted connections will be made with high strength bolts conforming to one of the following specifications:

A. "Specification for High-Strength Bolts for Structural Steel Joints," ASTM A325.

B. "Specification for Heat-Treated Steel Structural Bolts, 150 KSI Tensile Strength," ASTM A490.

Other bolts listed in ANSI/AISC N690 may also be used.

3.8.4.6.2 Quality Control

The quality of materials will be controlled by requiring the suppliers to furnish appropriate mill test reports as required under relevant ASTM Specifications as described in Subsection 3.8.4.6.1. These mill test reports will be reviewed and approved in accordance with the general provisions of the overall Quality Assurance Program outlined in Chapter 17 and supplemented by the special provisions of the appropriate codes and specifications for design listed in Table 3.8-4.

Erection tolerances, in general, will be in accordance with the referenced design code. Where special tolerances that influence the erection of equipment, etc., are required, they will be indicated on the drawings by the Engineer.

3.8.4.6.3 Special Construction Techniques

No unique or untried construction techniques are contemplated. Both the cylindrical and the dome portions of the shield building will be constructed using standard construction techniques.

3.8.4.7 Testing and In-service Surveillance Requirements

There will be no testing or in-service surveillance beyond those quality control tests performed during construction, which will be in accordance with ACI 349, ACI 301, ANSI/AISC N690 or ANSI N45.2.5 (Reference 8) as applicable.

3.8.5 FOUNDATIONS

3.8.5.1 Description of the Foundations

The foundations of the Category I structures are reinforced concrete mats. The foundation of the Nuclear Island is approximately 10 feet thick, has a flat bottom and rests on soil or rock. The top of the Nuclear Island basemat is located 40.75 feet ± 1 foot below the finished grade elevation. The minimum foundation mat thicknesses for the Diesel Generator Fuel Oil structure and Component Cooling Water Heat Exchanger structure are approximately 2 ~~foot~~ feet and 4 ~~foot~~ feet, respectively. V

The COL applicant will submit the site-specific foundation mat construction procedures in accordance with SRP 3.8.5.

3.8.5.2 Applicable Codes, Standards, and Specifications

Reinforced concrete foundations and supports of Category I structures are designed as described in Appendix 3.8A using the codes and criteria shown in Table 3.8-4.

3.8.5.3 Loads and Loading Combinations

The design loads and loading combinations are described in Section 3.8.4.3 and Appendix 3.8A.

3.8.5.4 Design and Analysis Procedures

The reinforced concrete foundations of Category I structures are analyzed and designed for the reactions due to static, seismic and all other significant loads at the base of the superstructures supported by the foundation in accordance with the criteria in Appendix 3.8A. The foundation mat is modeled as a three dimensional finite element structure as an integral part

TABLE 3.8-3

(Sheet 1 of 3)

STRESS INTENSITY LIMITS FOR STEEL CONTAINMENTS

Load Categories		Primary Stresses Gen. Mem. P_m	Local Mem. P_L	Bending & Local Mem. $P_b + P_L$ (6)	Primary & Secondary $P_L + P_b + Q$	Peak Stresses $P_L + P_b + Q + F$	Buckling
Testing Condition	Pneumatic	$0.75S_y$	$1.15S_y$	$1.15S_y$	N/A (2)	Consider for (5) fatigue evaluation	See (9)
Design Condition		$1.0S_{mc}$	$1.5S_{mc}$	$1.5S_{mc}$	N/A	N/A	See (9)
Level A Service Limit (1)		$1.0S_{mc}$	$1.5S_{mc}$	$1.5S_{mc}$	$3.0S_{mi}$	Consider for fatigue evaluation	See (9)

Delete

TABLE 3.8-3 (Cont'd)

(Sheet 2 of 3)

STRESS INTENSITY LIMITS FOR STEEL CONTAINMENTS

Load Categories			Primary Stresses Gen. Mem. P_m	Primary Stresses Local Mem. P_L	Bending & Local Mem. $P^b + P_L$ (6)	Primary & Secondary $P_L + P_b + Q$	Peak Stresses $P_L + P_b + Q + F$	Buckling
Level C Service Limit		Not integral and Continuous	$1.0S_{mc}$	$1.5S_{mc}$	$1.5S_{mc}$	$3.0S_{mi}$	N/A	See (9)
		Integral and Continuous (4) (7)	$1.2S_{mc}$ or * $1.0S_y$	$1.8S_{mc}$ or * $1.5S_y$	$1.8S_{mc}$ or * $1.5S_y$ (8)	N/A	N/A	See (9)
Level D Service Limit		Not integral and Continuous	$1.2S_{mc}$ or * $1.0S_y$	$1.8S_{mc}$ or * $1.5S_y$	$1.8S_{mc}$ or * $1.5S_y$	N/A	N/A	See (9)
	Integ. & Cont.	Elastic An. (3)	S_f	$1.5S_f$	$1.5S_f$	N/A	N/A	See (9)
		Inelastic An. (3)	S_f	S_f	S_f			
Post-Flooding			$1.2S_{mc}$ or * $1.0S_y$	$1.8S_{mc}$ or * $1.5S_y$	$1.8S_{mc}$ or * $1.5S_y$	$2.0S_{mi}$	N/A (2)	See (9)

Delete

STRESS INTENSITY LIMITS FOR STEEL CONTAINMENTS

NOTES:

(1) The allowable stress intensities S_{mi} and S_{mc} shall be those defined in Section NE of the ASME Code.

(2) N/A - No evaluation required.

(3) S_c is 85% of the general primary membrane allowable permitted in Appendix F. In the application of the rules of Appendix F, S_{mi}, if applicable, shall be as specified in Section NE of the ASME Code.

(4) Those limits identified by the asterisk (*) indicate a choice of the larger of the two limits.

(5) The number of test sequences shall not exceed 10 unless a fatigue evaluation is considered.

(6) Values shown are for a solid rectangular section. See NE-3220 for other than a solid rectangular section.

(7) These stress intensity limits apply to the partial penetration welds also.

(8) Values shown are applicable when $P_L < 0.67S_y$. When $P_L > 0.67S_y$, use the larger of the two limits, $[2.5-1.5(P_L/S_y)]1.2S_{mc}$ or $[2.5 - 1.5(P_L/S_y)]S_y$.

(9) It must be demonstrated that any axisymmetric techniques proposed are applicable to a vessel having large asymmetric openings, and that the overall margin of safety to prevent buckling is adequate.

Delete

TABLE 3.8-3C

STABILITY EVALUATION FOR THE STEEL CONTAINMENT VESSEL

Load Categories	Reduced Load Combination Equation	Calculated Safety Factor	Required Safety Factor
Level A	$D+L+P_a+T_a$	3.0	3.0
Level C	$D+L+P_a+E'$	2.7	2.5

Y

TABLE 3.8-5

(Sheet 1 of ~~10~~ 1)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

~~INDEX~~

~~I. Load Definitions~~

~~1. Normal Loads~~
~~2. Severe Environmental Loads~~
~~3. Extreme Environmental Loads~~
~~4. Abnormal Loads~~
~~5. Other Definitions~~

~~II. Load Combinations and Acceptance Criteria for Category I Concrete Structures~~

~~1. Service Load Conditions~~
~~2. Factored Load Conditions~~

~~III. Load Combinations and Acceptance Criteria for Category I Steel Structures~~

~~1. Service Load Conditions~~

~~a. Elastic Design~~
~~b. Plastic Design~~

~~2. Factored Load Conditions~~

~~a. Elastic Design~~
~~b. Plastic Design~~

~~IV. Load Combinations and Acceptance Criteria for Category I Foundations~~

Loads and load combinations for Seismic Category I structures are defined in Appendix 3.8A, Section 5.0.

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TABLE 3.8-5 (Cont'd)

(Sheet 2 of 10)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

I. Load Definitions

All the major loads to be encountered and/or to be postulated in a Category I structure are grouped into four categories described below. All the loads listed, however, are not necessarily applicable to all the structures and their elements in the plant. Loads and the applicable load combinations for which each structure is designed will depend on the conditions to which that particular structure could be subjected.

1. Normal Loads

Normal loads are those loads to be encountered during normal plant operation and shutdown. They include the following:

D --- Dead loads or their related internal moments and forces, including any permanent equipment loads and hydrostatic loads.

L --- Live loads or their related internal moments and forces, including any movable equipment loads and other loads which vary with intensity and occurrence, such as soil pressure.

F --- Lateral and Vertical forces associated with hydrostatic loading, either internal or external. For factored load combinations, only pressures due to normal fluid levels shall be combined with other extreme or abnormal loads.

H --- Lateral loads produced by static or seismic earth pressures.

T_o --- Thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

R_o --- Pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

2. Severe Environmental Loads

Severe environmental loads are those loads that could infrequently be encountered during the plant life. Included in this category are:

W --- Loads generated by the design wind specified for the plant.

Y

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TABLE 3.8-5 (Cont'd)

(Sheet 3 of 10)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

3. Extreme Environmental Loads

Extreme environmental loads are those which are credible but are highly improbable. The include:

E' --- Loads generated by the Safe Shutdown Earthquake. The loads consist of three directional loads, E'_x (N-S direction), E'_y (E-W direction), E'_z (vertical direction).

The earthquake loads are combined to obtain the maximum stress results by one of the following combinations:

(i) $E' = (E'^2_x + E'^2_y + E'^2_z)^{1/2}$

or

(ii) $E' = \pm E'_x \pm 0.4\ (E'_y \pm E'_z)$

or

$E'45 = \pm E'_y \pm 0.4\ (E'_x \pm E'_z)$

or

$E' = \pm E'_z \pm 0.4\ (E'_x \pm E'_y)$

W_t --- Loads generated by the Design Basis Tornado specified for the plant. They include loads due to the tornado wind pressure (W_w), loads due to the tornado-created differential pressures (W_p), and loads due to the tornado-generated missiles (W_m).

The combined effect of W_w, W_p, and W_m is determined in a conservative manner for each particular structure or portion thereof, as applicable, by using one or more of the following combinations as appropriate:

(i) $W_t = W_w$

(ii) $W_t = W_p$

(iii) $W_t = W_m$

(iv) $W_t = W_w + 0.5\ W_p$

(v) $W_t = W_w + W_m$

(vi) $W_t = W_w + 0.5\ W_p + W_m$

Delete

TABLE 3.8-5 (Cont'd)

(Sheet 4 of 10)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

4. Abnormal Loads

Abnormal loads are those loads generated by a postulated high energy pipe break accident within a building and/or compartment thereof. Included in this category are the following:

P_a --- Pressure equivalent static load within or across a compartment and/or building, generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

T_a --- Thermal loads under thermal conditions generated by the postulated break and including T_o.

R_a --- Pipe reactions under thermal conditions generated by the postulated break and including R_o.

Y_r --- Equivalent static load on the structure generated by the reaction of the broken high-energy pipe during the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_j --- Jet impingement equivalent static load on a structure generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_m --- Missile impact equivalent static load on a structure generated by or during the postulated break, such as pipe whipping, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

In determining an appropriate equivalent static load for Yr, Yj, and Ym, elastic-plastic behavior may be assumed with appropriate ductility ratios as long as excessive deflections will not result in loss of function of any safety related system.

5. Other Definitions

S --- For structural steel, S is the required section strength based on the elastic design methods and the allowable stresses defined in ANSI/AISC N690.

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TABLE 3.8-5 (Cont'd)

(Sheet 5 of 10)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

U --- For concrete structures, U is the section strength required to resist design loads based on the ultimate strength design method described in ACI 349-85.

Y --- For structural steel, Y is the section strength required to resist design loads based on plastic design methods described in ANSI/AISC N690-1984.

II. Load Combinations and Acceptance Criteria for Category I Concrete Structures

The following set of load combinations and allowable design limits is used for all Category I concrete structures:

1. Service Load Conditions

Service Load Conditions, represent Normal, Severe Environmental and Normal/Severe Environmental loads.

Y

The Ultimate Strength Design method is used with the following load combinations:

1) $U = 1.4D + 1.7F + 1.7L + 1.7H + 1.7R_o$

2) $U = 1.4D + 1.7F + 1.7L + 1.7H + 1.7R_o + 1.7W$

If thermal stresses due to T_o are present, the coefficients for each load category may be multiplied by 0.75 to satisfy the following combination:

3) $U = (0.75)(1.4D + 1.7F + 1.7L + 1.7H + 1.7T_o + 1.7R_o + 1.7W)$ or
$U = 1.05D + 1.05F + 1.3L + 1.3H + 1.3T_o + 1.3R_o + 1.3W$

In addition, the following combination is considered:

4) $U = 1.2D+1.7W$

Where any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise the coefficient for the load should be taken as zero.

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TABLE 3.8-5 (Cont'd)

(Sheet 6 of 10)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

2. Factored Load Conditions

Factor Load Conditions represent Extreme Environmental, Abnormal, Abnormal/Severe Environmental and Abnormal/Extreme Environmental loads. The Ultimate Strength Design method is used with the following load combinations:

1) $U = D + L + F + H + T_o + R_o + E'$

2) $U = D + L + F + H + T_o + R_o + W_t$

3) $U = D + L + F + H + T_a + R_a + 1.5\ P_a$

4) $U = D + L + F + H + T_a + R_a + 1.0P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.0E'$

In factored load combinations (3) and (4), the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, are used unless a time-history analysis is performed to justify otherwise. Factored load combinations (2) and (4) are satisfied first without the tornado missile load in (2), and without Y_r, Y_j, and Y_m in (4). When considering these loads, however, local section strength capacities may be exceeded under the effect of these concentrated loads, provided there will be no loss of function of any safety related system.

Where any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise the coefficient for the load should be taken as zero.

Where the structural effects of differential settlement, creep, or shrinkage may be significant, they should be included with the dead load, D, as applicable.

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TABLE 3.8-5 (Cont'd)

(Sheet 7 of 10)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

III. Load Combinations and Acceptance Criteria for Category I Steel Structures

The following set of load combinations and allowable design limits is used for all Category I steel structures:

1. Service Load Conditions

Either the elastic working stress design methods or the plastic design methods of ANSI/AISC N690 may be used.

a. If the elastic working stress design methods are used:

1) $S = D + L + F + H + R_o$

2) $S = D + L + F + H + R_o + W$

If thermal stresses due to T_o and R_o are present, the following combinations are also satisfied:

3) $1.3\ S = D + L + F + H + T_o + R_o$

4) $1.3\ S = D + L + F + H + T_o + R_o + W$

Both cases of L having its full value or being completely absent are checked.

b. If plastic design methods are used:

1) $Y = 1.7\ D + 1.7\ L + 1.7\ F + 1.7\ H + 1.7\ R_o$

2) $Y = 1.7\ D + 1.7\ L + 1.7\ F + 1.7\ H + 1.7\ R_o + 1.7\ W$

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TABLE 3.8-5 (Cont'd)

(Sheet 8 of 10)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

If thermal stresses due to To and Ro are present, the following combinations are also satisfied:

3) $Y = 1.3(D + L + F + H + T_o + R_o)$

4) $Y = 1.3(D + L + F + H + \bar{T}_o + R_o + W)$

Both cases of L having its full value or being completely absent are checked.

2. Factored Load Conditions

The following load combinations are satisfied:

a. If elastic working stress design methods are used:

1) $1.6\ S = D + F + L + H + T_o + R_o + E'$

2) $1.6\ S = D + F + L + H + T_o + R_o + W_t$

3) $1.6\ S = D + F + L + H + T_a + R_a + P_a$

4) $1.7\ S^* = D + F + L + H + T_a + R_a + P_a + 1.0(Y_j + Y_r + Y_m) + E'$

* For combination (4), in computing the required section strength, S, the plastic section modulus of steel shapes may be used.

b. If plastic design methods are used:

1) $Y^* = D + F + L + H + T_o + R_o + E'$

2) $Y^* = D + F + L + H + T_o + R_o + W_t$

3) $Y^* = D + F + L + H + T_a + R_a + 1.5\ P_a$

4) $Y^* = D + F + L + H + T_a + R_a + P_a + 1.0(Y_j+Y_r+Y_m) + E'$

Y

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TABLE 3.8-5 (Cont'd)

(Sheet 9 of 10)

LOAD COMBINATIONS FOR CATEGORY I STRUCTURES

In the above factored load combinations, thermal loads can be neglected when it can be shown that they are secondary and self-limiting in nature and where the material is ductile.

* Y(for the factored load combinations) should be multiplied by 0.90 for the Internal Structures and 1.0 for other Category I structures.

In factored load combinations (3) and (4), the minimum values of P_a, T_a, T_o, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, are used unless a time-history analysis is performed to justify otherwise. Factored load combinations (2) and (4) are first satisfied without the tornado missile load in (2), and without Y_r, Y_j, and Y_m in (4). When considering these loads, however, local section strengths may be exceeded under the effect of these concentrated loads, provided there will be no loss of function of any safety-related system.

Where any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9, if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load should be taken as zero.

Where the structural effect of differential settlement may be significant it should be included with the dead load, D.

IV. Load Combinations and Acceptance Criteria for Category I Foundations

In addition to the load combinations and acceptance criteria referenced above, all Category I foundations are also checked against sliding and overturning due to earthquakes, winds, and tornadoes and against flotation due to floods in accordance with the following:

	Minimum Factors of Safety		
Load Combination	Overturning	Sliding	Flotation
D + H + W	1.5	1.5	-
D + H + E'	1.1	1.1	-
D + H + W_t	1.1	1.1	-
D + F	-	-	1.1

Delete

~~TABLE 3.8-5 (Cont'd)~~

~~(Sheet 10 of 10)~~

~~LOAD COMBINATIONS FOR CATEGORY I STRUCTURES~~

~~Definitions:~~

~~D - Dead Load~~
~~F - Hydrostatic Forces of Design Basis Flood~~
~~H - Lateral Earth Pressure~~
~~E' - SSE Seismic Load~~
~~W - Wind Load~~
~~W_t - Tornado Load~~

TABLE OF CONTENTS (Cont'd)

APPENDIX 3.8A

Spacing

V

included in the certified design

1.0 INTRODUCTION

This appendix provides the criteria for the analysis and design of structures that comprise the System 80+ Standard Plant.

The information presented in this appendix shall be used in the analysis and design of Seismic Category I and II~~, Safety Class 3, and Seismic Category II Safety Class NNS,~~ structural components comprising the System 80+ Standard Plant structures ~~identified in Table 3.2-1~~. Design requirements for individual structures are based upon their seismic category and safety classifications listed in Table 3.2-1. The criteria for the Steel Containment Vessel are provided in Section 3.8.2 and are excluded from this appendix.

All structures required to shut down and maintain the reactor in a safe and orderly condition or prevent the uncontrolled release of excessive amounts of radioactivity following a Safe Shutdown Earthquake have a classification of Seismic Category I. These structures shall be designed to withstand, without loss of function, the most severe postulated plant accident or natural phenomena for the site.

Safety classifications are defined in Section 3.2.2. Structural components required as part of the primary containment pressure boundary or for its support and under the scope of the ASME Boiler and Pressure Vessel Code are Safety Class 2. All other structural components required to perform safety related functions are Safety Class 3. Safety Class 1 applies to the NSSS primary system components. Safety Classes 1 & 2 are not applicable within this appendix.

Those non-Seismic Category I structures capable of impairing the functioning of any Seismic Category I structures or component in the event of failure are classified as Seismic Category II. Seismic Category II structures are designed to prevent failure in the direction of a Seismic Category I structure or component under extreme environmental or accident conditions. The seismic design requirements for Category II structures under these conditions is equivalent to that of Seismic Category I structures.

covered by this appendix

and buried cable tunnels and conduit banks

Seismic Category I and II, Non-Nuclear Island structures include the Turbine Building, Diesel Fuel Storage Structure, Component Cooling Water (CCW) Heat Exchanger Structure, CCW Pipe Tunnel, Radwaste Facility, ~~and~~ Service Water Pumphouse & Intake Structure. Also included is the concrete dike surrounding the outside CVCS Boric Acid Storage Tank ~~(Seismic Category I, Safety Class 3)~~, Holdup Tank ~~(Safety Class NNS)~~, and Reactor Makeup Tank ~~(Safety Class NNS)~~.

The dike surrounding the Station Service Water Pond is site specific and is not addressed within this appendix.

~~The Non-Seismic Category I & II Structures include the Service Building, Auxiliary Boiler Structure, Administration Building, Warehouse, Condensate Storage Tank and dike, and Fire Pump House.~~

Primary structural components consist of concrete floors, roof slabs, foundation basemats, walls, beams, and columns. Steel beams and columns will be included within this appendix if their primary function is to provide support to walls, floors, or roof slabs. ~~Steel members whose primary function~~

Component support building structures

~~Equipment support~~ will meet the code requirements of this appendix. ~~but~~ Specific load and functional requirements ~~will be~~ are addressed under specific design criteria/specifications.

in Section 3.9.3.4 and Appendix 3.9A and

Information presented in this appendix is sufficiently comprehensive in nature to:

a. provide the criteria necessary to perform an analysis and translate that analysis into a final design, and

b. provide a correlation of analysis, design, and construction requirements with those in Sections 3.8.3, 3.8.4, and 3.8.5.

Miscellaneous components, while not primary structural components, must be considered in the design of primary components as to their loads and method of attachment. Design of these components is based upon the allowable loads and design requirements found in the ACI, ANSI, ASME and/or other specialized codes.

Design parameters or information indicated "(by COL)" are delegated to the Combined Operating License Applicant for completion as part of the site specific final design.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 DEFINITIONS

Combined Operating License	Combined Construction Permit and Operating License with conditions for a nuclear power facility issued in accordance 10CFR part 52 Subpart C.
Design Engineer	For this criteria, the person given responsibility by the Plant Designer to provide final approval for any structural design activity.
Exceedance Value	A value for a design parameter based upon a selected probability that the identified value will not be exceeded.
Plant Designer	A team of Architect Engineers and NSSS vendors who have the responsibility to develop and complete the System 80+ Standard Plant design.
Quality Class	QA program classifications as identified by ABB-CE and included in CESSAR-DC Table 3.2-1. Safety related Category I & II structures will be Quality Class 1.
Safety Class	Relative importance of fluid system components and related equipment as classified in ANSI ANS 51.1 (reference CESSAR-DC Section 3.2.2) Safety Classes 1, 2, 3, and NNS.

DGA	Diesel Generator Area V
~~DGA~~DS	Discharge Structure
EFW	Emergency Feedwater
EPRI	Electric Power Research Institute
FHA	Fuel Handling Area
FPH	Fire Pump House
FSAR	Final Safety Analysis Report
GDC	General Design Criteria/Criterion
HIC	High Integrity Container
HVAC	Heating Ventilation and Air Conditioning
HVT	Holdup Volume Tank
I&C(s)	Instrumentation & Control(s)
ICI	In-core Instrumentation
IRWST	In-Containment Refueling Water Storage Tank
IS	Intake Structure
ITAAC	Inspections, Tests, Analyses and Acceptance Criteria
LBB	Leak-Before-Break
MB	CVCS & Maintenance Area
MS	Main Steam Valve House
MX	Miscellaneous Buildings
NA	Nuclear Annex
NFPA	National Fire Protection Association
NI	Nuclear Island
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NUREG	NRC Technical Report Designation
PAP	Personnel Access Portal
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PRT	Pressurizer Relief Tank
PRZ	Pressurizer
QA	Quality Assurance
RA	Reactor Shield Building Annulus
RB/RXB	Reactor Building
RC	Reactor Building Steel Containment Vessel
RCP	Reactor Coolant Pump
RDT	Reactor Drain Tank
RFAI	Relay House
RS	Reactor Building Subsphere
RW	Radwaste Facility
SAR	Safety Analysis Report
SB	Station Service Building
SCS	Shutdown Cooling System
SD	Station Service Water Discharge Structure
SER	Safety Evaluation Report (NUREG-1462)
SF	Spent Fuel Storage Area
SG	Switch Gear Building
SI	Station Service Water Pump Structure

3.1.2.1 Containment Shield Building

The Containment Shield Building (see Section 10.2 of this appendix) is the concrete structure that surrounds the steel Containment Vessel and Reactor Building Subsphere and provides protection from postulated external missiles and other environmental effects. The Containment Shield Building provides an additional barrier against the release of fission products.

The Shield Building has a 105' inside radius, 4 feet thick, cylindrical reinforced concrete shell extending from the foundation basemat at El. 50'-0" to El. 146'-0". The cylindrical wall extends upward from El. 146' with a 3 ft thickness to the spring line at El. 157'-0". The Shield Building is topped by a 3 feet thick reinforced concrete hemispherical roof. The outside apex of the dome is at elevation 265'-0".

3.1.2.2 Reactor Building Subsphere

The Reactor Building Subsphere (see Section 10.3 of this appendix) is located inside the Shield Building and external to the Containment Vessel. The Subsphere consists of reinforced concrete walls and slabs and the Containment Support Pedestal. The purpose of the subsphere structures is to support the containment vessel and the Internal Structures and isolate safety related equipment.

3.1.2.3 Containment Internal Structures

The Containment Internal Structures (see Section 10.4 of this appendix) are located inside the spherical steel containment vessel. The purpose of these internal structures is to provide structural support, radiation and missile shielding, and space for the IRWST. These structures are constructed of reinforced concrete and structural steel. These structures are described in Section 3.8.3.1.

3.1.3 NUCLEAR ANNEX

The Nuclear Annex (see Section 10.5 of this appendix) is a multi-level reinforced concrete structure surrounding the Reactor Building. The Nuclear Annex is integral with the Containment Shield Building and provides lateral bracing while providing partial tornado wind and missile protection. The Nuclear Annex provides protected areas (Control Complex, Diesel Generator Area, Fuel Handling Area, CVCS Area, and Main Steam Valve House) for safety related equipment. Structural components provide biological shielding required as a result of handling nuclear fuel or processing radioactive wastes.

3.2 ~~OTHER~~ NON-NUCLEAR ISLAND SEISMIC CATEGORY I AND II STRUCTURES

Refer to Section 11.0 for detailed descriptions of the following:

- Diesel Fuel Storage Structure - Category I,
- Component Cooling Water Heat Exchanger Structure - Category I,
- Radwaste Facility - Category II,
- Service Water Pumphouse and Intake Structure - Category I,
- Turbine Building - Category II,

Equipment designated as a permanent dead load need not be physically attached provided its size and location are expected to remain constant.

5.1.1.1 D - Dead Load

Dead load refers to loads which are constant in magnitude and point of application. Dead loads are the mass of the structure plus any permanent~~ly attached~~ equipment loads. "D" may also refer to the internal forces and moments due to dead loads. The effects of differential settlement shall be considered with dead loads. *Hydrostatic loads from constant fluid levels shall be considered with dead loads.*

Uniform dead loads represent the structural mass, miscellaneous equipment, and distribution system (electrical cable trays and mechanical piping or HVAC) loads. Specific loads for designated equipment are represented by concentrated loads at the point of application.

5.1.1.2 L - Live Loads

Live load, also referred to as operating load, refers to any normal load that may vary with intensity and/or location of occurrence. Variable loads include movable equipment or equipment that is likely to be moved. "L" may also refer to the internal forces and moments due to live loads.

Live loads are applied to the structure as either concentrated or uniform loads. For equipment supports, live loads should also consider contributory loads due to the effects of vibration and any support movement. ~~Twenty-five percent of the live load shall be considered applicable for [illegible] load combinations.~~

Design drawings prepared by the COL applicant should show allowable loads for the designated laydown areas.

5.1.1.2.1 Precipitation

The minimum design live load due to precipitation (rain, snow, or ice) for Seismic Category I buildings shall be taken as 50 psf. This live load, equivalent to approximately 9½" of water, will be sufficient for the design peak rainfall of 19.4 in/hr or 6.2 in/5 min given in Table 2.0-1. The design load for rain shall also include the additional load that may result from ponding due to the deflection of the supporting roof or the blockage of the primary roof drains.

5.1.1.2.2 Compartmental Pressure Loads

Compartments shall be evaluated for the potential for internal pressurization. Pressure loads associated with tornadoes, LOCAs, or other explosive type loads shall be classified as extreme environmental or abnormal loads. See Sections 5.1.3.2.1 and 5.1.4.1.

5.1.1.2.3 Truck Loads

Loads due to vehicular traffic in designated truck bays is in accordance with standard AASHO truck loading or identified special loads. Special loads may consist of construction or maintenance loads or routine shipments of fuel casks or other high level radioactive waste.

Structural members and components required for the support of

5.1.1.2.4 Rail Loads

Design of the rail/truck bays is controlled by anticipated shipping weights.

5.1.1.2.5 Cranes, Elevators, and Other Hoists

and hoists

This criteria is applicable to permanently installed cranes required for station operation and maintenance as well as temporary construction cranes. The structural design shall consider the placement of construction hoists on floors, walls, and columns. Design loads shall include the full rated capacity of the hoists plus impact loads as well as test load requirements.

Test loads shall be evaluated as 125% of the crane rated capacity. The test loads shall be increased by an additional 25% to account for impact. Test loads shall be checked in Service Load combinations with a factor of 1.1 applied instead of the 1.7 factor normally applied to live loads. The factor is reduced because the test loads are known and the tests are performed under controlled conditions.

For construction cranes located adjacent to the structure, the structural design shall include soil surcharge loads produced by the full load of the crane. Cranes permanently mounted to structures shall be identified on general arrangement drawings.

Pendant operated traveling cranes and trolley hoists shall be designed for 110% of the rated load capacity, to account for impact as required by ANSI N690 Section Q1.3.2. Design loads for motor operated trolleys and cab operated traveling cranes shall be increased by 25% of the rated load capacity to account for impact in Service and Factored load combinations.

Minimum lateral design loads on crane runways shall be 20% of the sum of the rated hoist capacity plus the weight of the crane trolley to account for the effects of the moving trolley. Load shall be applied at the top of the rail in either direction and distributed according to the relative stiffnesses of the end supports.

Minimum longitudinal load on each crane rail shall be 10% of the maximum crane wheel loads.

Elevators live loads shall be increased by 100% for design of supports.

5.1.1.2.6 Load Allowances for Cable Trays

Loads to be applied in areas where multiple cable tray runs are identified include:

- 7 kips at mid-span on steel beams and columns.
- 7 kips at a spacing of 8 ft on center for slabs.

Acceptability of these design loads will be determined through review of the final electrical layout drawings prepared by the COL applicant.

¶ Acceptability of these design loads will be verified through review of the final plant configuration.

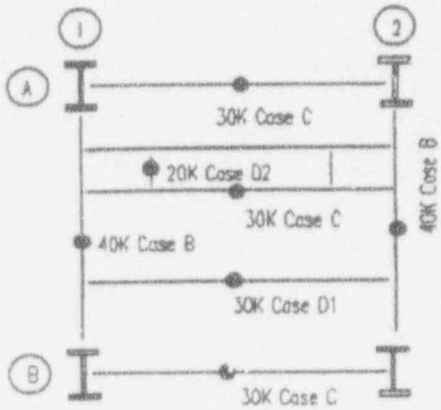
5.1.1.2.7 Miscellaneous Equipment and Large Bore Piping

The following load allowances shall be considered where multiple large bore piping runs are located or where large temporary loads are identified.

- In addition to major equipment located on general arrangement drawings, a point load of 20 kips should be applied at the midpoint of each concrete floor slab and concrete beams (Case A).

- A point load of 40 kips shall be applied at the midpoint of steel collector beams providing primary framing (Case B).

- A point load of 30 kips shall be applied to the midpoint of other steel collector beams or beams provided for support framing (Case C).



- A point load of 30 kips at midspan on primary steel filler beams framing into steel collector beams (Case D1) and 20 kips on other steel filler beams or stringers (Case D2). (Note: These loads are for added design margin on the beams and slabs and are not to be carried beyond the beam support connection to the supporting beam or column.)

- A contingency load of 80 kips should be applied to the top of each steel column.

5.1.1.2.8 Miscellaneous Equipment, Small Bore Piping, Cable Tray, and HVAC Ductwork

The following load allowances should be included for areas with multiple runs of small bore piping, cable tray, or HVAC ducts.

- A load of 15 kips on steel collector beams
- A load of 5 kips on other steel beams
- A load of 50 kips on steel columns

5.1.1.3 H - Soil Load

Replace with attached Section 5.1.1.3

~~Lateral soil pressure shall be based upon the soil density and shall include the effects of ground water in accordance with section 5.1.1.4 of this appendix. Normal soil loads shall consider a ground water level up to El. 88'-9", 2'-0" below plant finished yard grade elevation (El. 90'-9"). The lateral soil pressure shall be based upon the following soil properties:~~

- ~~Soil Density~~
  ~~125 pounds per cubic foot (pcf), normal moist soil~~
  ~~80 pcf. dry~~
  ~~145 pcf saturated~~

Replace with attached Section 5.1.1.3

- Angle of internal friction, ϕ; 30°
- Coefficient of friction, concrete on soil; use $\mu = 0.5$ assuming concrete is poured directly on competent structural backfill without any intervening material, such as waterproofing.
- The at-rest soil pressure shall be calculated using a coefficient of earth pressure at rest, K_0, of 0.5.
- The coefficient of passive earth pressure, K_p, shall be determined based upon the angle of internal friction, ϕ. $K_p = \tan^2(45° + \phi/2)$. The effects of buildings, vehicles, cranes, material stockpiles, etc. acting as surcharge loads on the soil adjacent to exterior building walls shall also be considered.

For factored load combinations the lateral soil load shall be based upon saturated soil associated with flooding and a ground water level 1'-0" below the plant finished yard grade.

5.1.1.4 F - Hydrostatic Loads

Hydrostatic loads are due to ground water, exterior flood waters, or fluid ~~retention~~ with fluctuating levels in internal compartments, including internal flooding.

Maximum flood level is specified to be 1'-0" below finished plant grade. Site specific flood elevations greater than this will be addressed by the COL applicant.

5.1.1.5 To - Thermal Loads

Thermal effects consist of thermally induced forces and moments resulting from plant operation or environmental conditions. Thermal loads and their effects are based on the critical transient or steady state condition. Thermal expansion loads due to axial restraint as well as loads resulting from thermal gradients shall be considered.

The following ambient temperature values during normal conditions shall be used as a basis for design. Site specific provisions may be taken to minimize the effects of the structural temperature gradients produced by these conditions.

External ambient conditions, reference Table 2.0-1.

Outside air temperatures -	100°F max. -10°F min.
Ground Temperature-	50°F

Internal ambient conditions, reference Appendix 3.11A and Sections 10 and 11 of this appendix.

Thermal analysis may be performed to determine concrete surface temperatures.

The friction coefficient shall be further reduced when intervening materials are used.

APPENDIX 3.8A

5.1.1.3 H-Soil Load

Lateral soil pressure shall be based upon the soil density and shall include the effects of ground water in accordance with section 5.1.1.4 of this appendix. Normal soil loads shall consider a ground water level up to El. 88'-9", 2'-0" below plant finished yard grade elevation (El. 90'-9").

- Soil Density (γ): Saturated Soil = 145 pcf (pounds/cubic foot)
  Moist Soil = 125 pcf
  Dry Soil = 80 pcf
- Angle of Internal Friction: $\phi = 30°$
- Coefficient of friction: μ = tan ϕ (i.e. 0.57) ~~[illegible]~~ assuming the concrete is poured directly on competent structural backfill without any intervening material, such as waterproofing; $\mu = \frac{2}{3}\tan\phi$ if concrete is not poured directly onto the soil.
- At-rest lateral soil pressure coefficient: $K_0 = 0.5$ (Used in Service Load Combinations)
- Active lateral soil pressure coefficient : $K_A = \tan^2(45° - \phi/2)$
- Passive lateral soil pressure coefficient: $K_P = \tan^2(45° + \phi/2)$
- Active lateral earthquake soil pressure coefficient: K_{AE}

$$K_{AE} = \frac{\sin^2(\phi+\beta-\theta')}{\cos(\theta')\sin^2(\beta)\sin(\beta-\theta'-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\theta'-\alpha)}{\sin(\beta-\delta-\theta')\sin(\alpha+\beta)}}\right]^2}$$

- Passive lateral earthquake soil pressure coefficient: K_{PE}

$$K_{PE} = \frac{\sin^2(\beta+\theta'-\phi)}{\cos(\theta')\sin^2(\beta)\sin(\delta+\beta+\theta'-90)\left[1-\sqrt{\frac{\sin(\phi+\delta)\sin(\phi+\alpha-\theta')}{\sin(\beta+\delta+\theta')\sin(\alpha+\beta)}}\right]^2}$$

where:

$$\theta' = \tan^{-1}\frac{k_h}{(1-k_v)}$$

$k_h = \frac{\text{average horizontal earthquake acceleration component}}{\text{acceleration due to gravity, g}}$

$k_v = \frac{\text{average vertical earthquake acceleration component}}{\text{acceleration due to gravity, g}}$

APPENDIX 3.8A

5.1.1.3 (CONT'D)

α = the slope or angle of the backfill surface as measured from the horizontal

β = (1) The angle formed by the exterior face of the wall and the horizontal. (2) The angle shall be measured as 180° minus the angle formed by the exterior wall surface and the horizontal direction extending out under the backfill. (3) This value will be 90° for vertical walls.

δ = the angle of wall friction is a quantitative value, expressed in degrees, used to define the level of friction between soil backfill and the retaining structure

The total lateral earth pressure is calculated as;

- At-rest lateral soil pressure: $P_o = ½K_o\gamma H^2$
- Active lateral soil pressure: $P_A = ½K_A\gamma H^2$
- Passive lateral soil pressure: $P_P = ½K_P\gamma H^2$
- Active lateral earthquake soil pressure: $P_{AE} = ½K_{AE}\gamma H^2(1\pm k_v)$
- Passive lateral earthquake soil pressure: $P_{PE} = ½K_{PE}\gamma H^2(1\pm k_v)$

V

where: γ = soil density (pcf)

H = height of soil-wall interface (ft)

REFERENCE: DAS, B.M., PRINCIPLES OF FOUNDATION ENGINEERING SECOND ED., PWS-KENT PUBLISHING CO., BOSTON, 1990.

The effects of buildings, vehicles, cranes, material stockpiles, etc. acting as surcharge loads on the soil adjacent to exterior building walls shall also be considered.

For factored load combinations the lateral soil load shall be based upon saturated soil associated with flooding and a ground water level 1'-0" below the finished plant yard.

The full potential live load shall be used for local analyses of structural members.

5.1.3.1 E' - Safe Shutdown Earthquake (SSE)

SSE loads are loads generated by an earthquake with a peak horizontal ground acceleration of 0.30g. Refer to Section 2.5.2.5.1 of CESSAR-DC.

Total loads for E' shall consider simultaneous seismic accelerations acting in three orthogonal directions (two horizontal and one vertical). Each of the three directional components of the earthquakes will produce responses in all three directions. Colinear responses due to each of the 3 individual earthquakes may be combined using the "Square Root of the Sum of the Squares" (SRSS) method. The resultant nodal loads are applied simultaneously to the structure. The seismic forces and moments may also be combined simultaneously using directional combination participation factors of 100%/40%/40% applied to the individual loads produced as a result of each earthquake to produce the design SSE loads. The critical load combination would use 100% of the loads due to one earthquake and 40% due to the other 2 earthquakes, i.e., Σ of F_x due to $\pm 100\%E'_x$ $\pm 40\%E'_y$ $\pm 40\%E'_z$.

SSE loads are obtained by multiplying the dead load and 25% of the design live load by the structural acceleration obtained from the seismic analysis of the structure. Amplification of these accelerations due to flexibility of structural members should be considered. Construction loads are not required to be included when determining seismic loads. Other temporary loads must be evaluated for applicability on a case by case basis.

¶ Seismic soil loads shall be used in combination with E'.

~~Construction loads are not required to be included when determining seismic loads. Other temporary loads must be evaluated for applicability on a case by case basis.~~

SSE damping values used in design (Reference NRC Reg Guide 1.61 and Table 3.7-1) shall be as follows:

Structure Type	% of Critical Damping
Welded Steel	4
Bolted Steel	7
Reinforced Concrete	7
Prestressed Concrete	5
Equipment (steel assembly)	3

Fluid sloshing loads in the IRWST, Spent Fuel Pool, and all other fluid reservoirs due to the SSE shall be considered in accordance with ASCE 4-86.

5.1.3.2 W_t - Tornado Loads

Loads generated by the design tornado are as identified in Section 3.3.2. Tornado loads include loads due to the tornado wind pressure (W_w), the tornado created differential pressure (W_p), and tornado-generated missiles (W_m). Twenty-five percent of the design live load shall be considered with tornado load combinations. The full potential live load is used for local analyses of structural members.

Design for missile impacts shall be in accordance with Section 3.5.3 and ACI 349, Appendix C. Minimum concrete wall and roof thicknesses shall be in accordance with Standard Review Plan 3.5.3 Table 1. Non-Category I structures shall not be assumed to shield seismic Category I structures from tornado wind, differential pressure, or missile loads.

5.1.4 ABNORMAL LOADS

Abnormal loads are those loads generated by a postulated high-energy pipe break accident. This event is classified as a "Design Basis Accident". Included in this category are: Pressure loads (P_a), Thermal loads (T_a), Pipe reactions (R_a), Load on the structure generated by the reaction on the pipe (Y_r), Jet impingement loads (Y_j), and Missile impact loads (Y_m). These loads are defined by:

- P_a - Pressure equivalent static load within or across a compartment and/or building, generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

- T_a - Thermal loads generated by the postulated break and including T_o.

- R_a - Pipe reactions generated by the postulated break and including R_o.

- Y_r - Equivalent static load on the structure generated by reaction of the broken high-energy pipe during the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

- Y_j - Jet impingement equivalent static load on a structure generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

- Y_m - Missile impact equivalent static load on the structure generated by or during the postulated break, such as pipe whipping, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

5.2 DESIGN LOAD COMBINATIONS

5.2.1 GENERAL

The following loading combinations ~~from Table 3.8-1~~ shall be used for analysis and design of Category I structures and their components.

Live loads shall be applied (fully or partially), removed, or shifted in location and pattern as necessary to obtain the worst case loading conditions for maximizing internal moments and forces for all load combinations. Impact forces due to moving loads shall be applied where appropriate.

Where any load is determined to have a mitigating effect on the overall loading for a steel or concrete structural member, a load coefficient of 0.9 should be applied to that load component. The reducing coefficient should be used only for that load which can be demonstrated to be always present or occurring simultaneously with other loads. For loads which cannot be shown to be always present, Ductility ratios determined from ACI 349 Appendix C should be used. Deflections shall be evaluated for potential loss of function for safety related systems.

Load combination 5.2.2.2 b) shall first be satisfied without the tornado missile load. Load combination, 5.2.2.2 d) shall first be satisfied without the Y loads. When including these loads however, local section strength capacities may be exceeded under the effect of these concentrated loads, provided there will be no loss of function of any safety related system.

Structural effects of differential settlement, creep, or shrinkage shall be included with the dead load.

5.2.3 LOADING COMBINATIONS FOR SEISMIC CATEGORY I STEEL STRUCTURES

The following set of load combinations define design requirements used for all Seismic Category I steel structures.

5.2.3.1 Service Load Conditions

5.2.3.1.1 If elastic allowable strength design methods are used:

a) $S = D + F + L + H$
b) $S = D + F + L + H + W$

If thermal stresses due to T_o and R_o are present, the following combinations are also satisfied:
c) $1.5\,S = D + F + L + H + R_o + T_o$ (tension members)
~~c)~~ $1.3\,S = D + F + L + H + R_o + T_o$ (compression members)
d) $1.5\,\cancel{1.3}\,S = D + F + L + H + R_o + T_o + W$ (tension members)
$1.3\,S = D + F + L + H + R_o + T_o + W$ (compression members)

For steel members, S is the required section strength based on the elastic design methods and the allowable stresses defined in Part 1 of ANSI/AISC N690

5.2.3.1.2 If plastic design methods are used:

a) $Y = 1.7\,(D + F + L + H)$
b) $Y = 1.7\,(D + F + L + H + W)$
c) $Y = 1.3\,(D + F + L + H + T_o + R_o)$
d) $Y = 1.3\,(D + F + L + H + T_o + R_o + W)$

For steel members Y is the section strength required to resist design loads based on the plastic design methods described in Part 2 of ANSI/AISC N690.

$\{1.4S = D+F+L+H+R_a+T_a+P_a$ (compression members)

$\{1.4S = D+F+L+H+R_o+T_o+W_t$ (compression members)

5.2.3.2 **Factored Load Conditions**

5.2.3.2.1 If elastic allowable strength design methods are used:

a) $1.6S = D + F + L + H + R_o + T_o + E'$ (tension members)

~~a)~~ $1.4\ S = D + F + L + H + R_o + T_o + E'$ (compression members)

b) 1.6 ~~1.4~~ $S = D + F + L + H + R_o + T_o + W_t$ (tension members)

(refer to item 5.2.2.2 b) for components of W_t)

c) 1.6 ~~1.4~~ $S = D + F + L + H + R_a + T_a + P_a$ (tension members)

d) 1.7 ~~1.6~~ $S = D + F + L + H + R_a + T_a + (Y_r+Y_j+Y_m) + E' + P_a$ (tension members)

$1.6S = D+F+L+H+R_a+T_a+(Y_r+Y_j+Y_m)+E'+P_a$ (compression members)

(The plastic section modulus for steel shapes may be used for this load combination.)

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5.2.3.2.2 If plastic design methods are used:

a) $Y^* = 1.0\ (D + F + L + H + Ro + To + E')$

b) $Y^* = 1.0\ (D + F + L + H + R_o + T_o + W_t)$
(refer to item 5.2.2.2 b) for components of W_t)

c) $Y^* = 1.0\ (D + F + L + H + R_a + T_a + 1.5\ P_a)$

d) $Y^* = 1.0\ (D + F + L + H + R_a + T_a + Y_r + Y_j + Y_m + E' + P_a)$

*use 0.9Y for Internal Structures and 1.0 for all other Category I structures. - (Reference SRP 3.8.3.II.5)

5.2.4 LOADING COMBINATIONS FOR SLIDING, OVERTURNING, AND FLOTATION

Minimum Factors of Safety

Load Combination	Overturning	Sliding	Flotation
D + H + W	1.5	1.5	-
$D + H + W_t$	1.1	1.1	-
D + H + E'	1.1	1.1	-
D + F	-	-	1.1

~~[illegible]~~

5.2.5 CONSTRUCTION LOAD COMBINATIONS

Service load combinations shall be used to evaluate construction methods and sequence and determine structural integrity of the partially erected structures.

5.2.6 APPLICABILITY OF LOADS

Lateral loads due to soil bearing pressure shall apply to all exterior walls up to El. 90'-9".

Structure Interaction (SSI) analyses described in Section 3.7B. For each elevation these ZPA values are enveloped from the values of each stick in the SSI model at the corresponding elevation. This enveloping of ZPA values at each elevation is repeated for all control motions and all soil cases, and a final envelope of ZPA values for each elevation is determined. The ZPA values are further amplified where necessary to account for floor slab flexibility. Figures 3.8A-3 through 3.8A-5 show this envelope profile for the NS, EW and vertical directions respectively. This envelope of ZPA values is applied as a uniform factor to the floor mass and contributing portions of the wall masses at each elevation within the structure as the applied seismic loading.

For the soft soil model this envelope loading is obtained from an envelope of soil cases B-2, C-2, C-3 and C-1.5. These soil cases represent the soft soil site category. Applying the envelope of the soft soil ZPA values is compatible with the soil stiffness modeled for the soft soils.

The enveloping ZPAs are used in the local analyses to determine the forces and moments from the inertia loads. The masses in the local models are accelerated by the appropriate ZPA value for the elevation being analyzed and the forces are applied as static point loads, static body forces, or static uniformly distributed loads.

For each load the response from all three directional earthquakes are combined simultaneously. The independent directional responses are combined using the square root of the sum of the squares (SRSS) method or the 100-40-40 Percent Rule described in ASCE 4-86. The 100-40-40 Rule is based on the observation that the maximum increase in the resultant for two orthogonal forces occurs when these forces are equal. The maximum value is 1.4 times one component. All possible combinations of the three orthogonal responses are considered. The 100-40-40 combination is expressed mathematically as:

$$R = (\pm 1.0R_X \pm 0.4R_Y \pm 0.4R_Z)$$

or,

$$R = (\pm 0.4R_X \pm 1.0R_Y \pm 0.4R_Z)$$

or,

$$R = (\pm 0.4R_X \pm 0.4R_Y \pm 1.0R_Z)$$

The 100-40-40 Percent Rule may also be applied for combining responses in the same direction due to different components of motion.

Additional seismic loads due to accidental torsion is accounted for as required by SRP Section 3.7.2.II.11. This accounts for variations in material densities, member sizes, architectural variations, equipment loads, etc., from design assumptions. Due to these potential variations, an additional eccentricity of the mass at each floor equivalent to 5% of the maximum building dimension is included. The accidental torsion load is an additional shear force at each floor elevation determined based on a percentage of total accumulated shear at each elevation.

The dynamic increment for horizontal soil loads on the exterior walls of the Nuclear Island, CCW heat exchanger structure and diesel fuel storage structure is determined from the 2D SSI analyses as described in Section 3.7. For other structures, the elastic solution method in ASCE 4-86 is used. IV

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¶ Concrete expansion anchors shall meet the requirements of Section 3.8.4.5.1.

- Transverse reinforcing at the edges of wall panels shall be anchored in accordance with Paragraphs 21.5.3.5 and 21.5.3.6

- Longitudinal reinforcing for beams shall be anchored according to Paragraph 21.6.1.3 with hoop reinforcement per Paragraph 21.6.2.1

- Development lengths for reinforcing will be according to Paragraph 21.6.4.

Epoxy coated reinforcing shall be used for exterior walls and slabs when the existing groundwater is determined to be sufficiently corrosive so as to adversely affect the long term durability of the concrete structure. The required splice length given in ACI 349 Section 12.2.2 shall be increased using factors provided in ACI 318 Section 12.2.4.3.

When feasible, uniform reinforcement patterns should be used for sections with similar requirements, thickness and loading.

6.2.1.1.2 Concrete Expansion Anchors

~~Expansion anchors shall be of the wedge, sleeve, or undercut design as specified in Section 3.8.4.5. Minimum design safety factors shall be:~~

- ~~4.0 for wedge and sleeve type anchors~~
- ~~3.0 for undercut type anchors~~

~~Expansion anchor embedments shall have a minimum factor of safety of 1.5 for concrete failure with respect to anchor minimum tensile strength.~~

~~Selection of expansion anchors shall consider energy absorption capability (i.e. ductility) of the anchors.~~

A specification for the design, installation, and use of expansion anchors should be developed by the COL Applicant and include;

- expansion anchor allowable loads,
- expansion anchor minimum spacing,
- spacing requirements for expansion anchors,
- procedures for addressing baseplate flexibility's in calculating design loads on expansion anchors,
- procedures for addressing shear tension interaction, and
- required load reductions for cyclic loadings.

When high capacity concrete anchors are specified, they should be of the direct bearing or "undercut" type. Load transfer for these anchors is achieved by bearing of the expanded embedded tip against the undercut concrete hole produced by a special flaring tool. Undercutting of the concrete is required for the anchor to provide the concrete shear capacity to match the high strength bolts.

For smaller safety related or non-safety related applications expansion anchors referred to as "Sleeves" or "Wedges" may be used, subject to the safety factors given ~~above~~ in Section 3.8.4.5.1.

6.2.1.2 Steel

The design of Category I steel structures and/or components shall use Allowable Strength Design methods in accordance with ANSI/AISC N690~~. Supplemental requirements (reference Section 3.8.4.5) are:~~ as amended by Section 3.8.4.5.2.

- ~~"Secondary Stresses" applies only to temperature loadings, Q1.0.2.~~
- ~~Additional notes for Section Q1.3.~~
- ~~Effects due to differential settlement shall be included with dead loads.~~
- ~~Offsetting loads in any load combination shall have a load factor of 0.0 unless they are always present or act simultaneously with other loads in which case the factor should be 0.9.~~
- ~~Stress limit coefficients are modified as shown in Section 5.2.3.1(2c) & d) and Section 5.2.3.2.1, Table Q1.5.7.1.~~
- ~~Change load factor for P_a in equation 5.2.3.2.2 to $1.37P_a$, Sec Q2.1 (equivalent to $1.5/1.1xP_a$).~~
- ~~Painting requirements as given in Section Q1.24 and Q1.25 shall be supplemented by the following:~~

  ~~Paintings or coatings for structural steel shall meet the requirements of Regulatory Guide 1.54 and ANSI/AICE N101.4, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities". As a supplemental requirement to ANSI N690, steel materials are to be shop painted, prior to delivery, in accordance with Section M3 of the AISC MANUAL OF STEEL CONSTRUCTION, "Allowable Stress Design" and its Commentary. Steel surfaces exposed after installation are to be field painted or coated in accordance with this same reference.~~

- ~~Ductility factors (μ) in Table Q1.5.8.1 shall not apply to constrained (rotation and/or displacement) members under load combinations 5.2.3.2.2d). Ductility factors from Appendix A, II.2 of SRP Section 3.5.3 shall be substituted for Table Q1.5.8.1.~~

Uniform depths of steel beams and connections should be maintained.

Bolted connections should be used for field erection of structural steel beams and columns. Load indicator bolts are recommended. The design of bolted connections shall be in accordance with ANSI N690 Section Q1.16 and the "Specification for Structural Joints Using ASTM A325 or A490 Bolts". Bolted connections shall be designed to be "slip critical" unless justified otherwise.

The requirements for welded connections are defined in Section 7.2.3 of this appendix. Welded connections ~~shall be designed in accordance with ANSI N690 Section Q1.15 and AWS D1.1~~.

Maximum utilization of shop fabricated connections should be considered to avoid welding in hazardous environments.

Transverse welds across the flanges of rolled Sections of Seismic Category I or II steel members are prohibited without approval of the design engineer. All transverse welds on Category I or II members shall be shown on approved drawings.

Structural members with restrained end conditions and thermal loads shall be evaluated for potential buckling.

6.2.1.3 Missile Protection

Exterior walls and roof slabs of Seismic Category I structures are required to function as missile barriers for tornado generated missiles. Design of missile barriers shall assure that the structure will not collapse under the missile load nor will there be penetration through the barrier. Safety related structures, systems and components shall be protected from secondary missiles as a result of backface scabbing. Interior walls and floors shall be evaluated and designed to function as missile barriers if required.

6.2.1.4 Fire Protection

Fire protection is provided in the form of fire rated walls and barriers as identified in Figure 3.8-5. In addition to passive fire protection offered by fire rated structural barriers, the structural design shall offer protection to the active fire suppression system to assure that they will not be made inoperable due to the failure of any structural member.

6.2.1.5 Flooding

Flooding is addressed in Section 3.4.4. Flood barriers are identified in Figure 3.8-5.

Protection of the Seismic Category I structures against flooding shall be insured by;

- allowing no access openings in the exterior walls lower than 1 foot above plant grade
- having no unsealed exterior wall or floor penetrations below plant flood level (El. 89'-9", 1 foot below finished yard grade)
- having water stops in all below grade exterior construction joints
- providing floor drainage

6.2.1.6 Construction Support

Cost saving may be achieved by reducing the duration of the construction schedule. Durations may be reduced by standardizing details and using modular designs that will allow offsite fabrication and assembly. Modular designs must consider transportability to the point of installation. Connections/fit-ups with previously erected components must be considered.

6.2.1.7 Security

10CFR Chapter I Part 73 provides the regulatory requirements for physical protection of the plant against sabotage as a result of unauthorized access. Plant designs shall prevent use of unauthorized access routes. In accordance with Part 73 Section 45(f)(1)(i), barriers shall be provided to channel access through protected area entry control points or delay any unauthorized penetration attempt sufficiently to allow detection by security personnel.

6.2.2 SPECIAL DESIGN CRITERIA

6.2.2.1 Radiation/Contamination Control

The design of structural elements shall provide surface features to prevent the spread of contamination and facilitate plant cleanup. Sumps for drain lines that may collect potentially contaminated liquids will be lined with stainless steel over the potentially wetted surface. Concrete surfaces should be protected by a smooth surface epoxy coating where the potential exists for contamination.

6.2.2.6.2 Electrical Cable Tray and HVAC Ductwork

Design of building structures ~~[illegible]~~ for support of cable trays and HVAC ductwork, shall meet the requirements of Appendix 3.9A. √

6.2.2.6.3 Support/Restraints for Piping and Its Components

Design of building structures ~~structural steel~~ for support~~ing~~ of piping and its components shall meet the requirements of Appendix 3.9A. √

6.2.2.6.4 Fabricated Embedments

The walls and floors of Seismic Category I Structures shall be provided with embedments for the mounting or attachment of structures and components. Additional typical embedments should be provided for welding structural attachments which will reduce the number of attachments utilizing expansion anchors. Tolerances for fabrication and installation of embedments shall be provided on design drawings or in specifications issued by the COL Applicant.

The anchorage for structural embedments shall be designed based upon ACI 349, Appendix B with the following exception. The assumed concrete failure cone projects out at an angle of 35° instead of 45°. The angle shall be measured from the plane normal to the axis of the embedment. This exception applies to structural embedments and headed anchors, such as "NELSON Studs", and expansion anchors. The exception is to prevent an overlapping of the concrete shear cones when anchors are spaced at a "2d" spacing (reference Section 3.8.4.5) and to avoid a less than required minimum edge distance.

A reduction in load capacity for embedments shall be applied for placement of anchors in the tension zone of concrete members.

7.0 CONSTRUCTION; FORMING, FABRICATION, AND ERECTION

7.1 CONCRETE

Concrete work for Seismic Category I structures shall conform to all requirements of ACI 349 and ACI 301 except as modified by this appendix.

7.1.1 CONCRETE MIX DESIGN

Concrete mix design for Seismic Category I structures, see Section 9.2 of this appendix, shall be determined based upon field testing of trial mixtures with the materials to be used. Testing shall evaluate;

- ultimate concrete strength as well as early strength in support of an aggressive construction schedule,
- concrete workability and consistency,
- required concrete admixtures,
- heat of hydration and required temperature control for large or thick concrete pours, and
- special exposure requirements when identified on design drawings.

7.1.2 CONCRETE PLACEMENT

Requirements and/or limitations on concrete placement will be determined in conjunction with the construction schedule. A site specific construction specification should be prepared by the COL Applicant to address requirements and procedures for concrete placement.

The concrete specification should address;

- desired volume of concrete pours and rate of deposition,
- special forming requirements,
- maximum height of pours,
- temperature limitations; weather conditions and concrete mix, including approved methods for temperature control, and
- curing requirements and procedures.

7.1.3 REINFORCING

Fabrication and placing of reinforcing bars for concrete in Seismic Category I structures shall conform to the requirements and tolerances specified in ACI 349 Section 7.5 and in ACI 301 Sections 5.5, 5.6, and 5.7.

Consideration shall be given for modular assemblies of reinforcing. Such assemblies shall be designed to be moved without changing their alignment.

Lap splices shall be prohibited for locations with tension stresses normal to the plane for the splice and for bar sizes greater than #11, except as provide by ACI 349 Section 12.14.2.1.

Welding of reinforcing shall be prohibited except as provided for in approved splice details. Welding shall conform to the requirements of AWS D1.4, "Structural Welding Code - Reinforcing Steel." Welded reinforcing shall be shown on reinforcing drawing details.

7.1.4 CONSTRUCTION SEQUENCING

Construction sequence will be determined by the COL Applicant. Additional design requirements due to the construction sequence will be determined by the COL Applicant during the final design.

7.2 STRUCTURAL STEEL

7.2.1 STRUCTURAL STEEL; FABRICATION AND ERECTION

Fabrication and erection of safety related steel members shall be in accordance with AISC N690, Sections Q1.23 and Q1.25. Additional requirements are applicable as provided for in this appendix.

7.2.2 HIGH STRENGTH BOLTED CONNECTIONS

Bolts shall be installed and tightened in accordance with Section 8(d) of "Specification for Structural Joints Using ASTM A325 or A490 Bolts." The use of "load indicator" bolts or washers should be used where possible. "Snug tight" installation of bolts in "slip critical" connections shall not be permitted.

7.2.3 WELDED CONNECTIONS

Welding activities associated with Seismic Category I structural steel and their connections shall be accomplished in accordance with written procedures and shall meet the requirements of ~~ANSI/AISC N690 Section Q1.17~~. | V

INSERT D

8.0 STRUCTURAL ACCEPTANCE CRITERIA

Structural Acceptance Criteria are specified in Section 3.8.4.5.

Separation Criteria for Seismic Category I and non-Seismic Category structures and components shall be verified.

9.0 MATERIALS

9.1 GENERAL

Material shall conform to requirements for Section 3.8.4.6.1 and this appendix.

Materials used should be selected based upon a proven record of service in other nuclear facilities. Materials shall be specified based upon approved codes and standards. Additional material restrictions or requirements may be added by the design engineer to meet anticipated design or field conditions.

With suitable qualification and no applicable material restrictions, substitute materials may be used.

Materials used shall be qualified to withstand environmental conditions for normal and accident conditions. Site specific design specifications prepared by the COL Applicant should identify required qualifying environmental conditions.

9.2 SPECIFICATIONS

The materials identified below and in Section 3.8.4.6.1 shall be considered acceptable for the analysis and design of System 80+ Standard Plant structures.

Additional materials may be added to this criteria when qualified by appropriate codes and standards.

9.2.1 CONCRETE

Concrete - compressive strength = 4000 psi
(5000 psi for the Nuclear Island superstructure)
Normal weight concrete with a density of 135 to 160 pcf.

Cement - material shall conform to ASTM C 150 per ACI 349 par. 3.2. Cement shall conform to Type I or Type II designations except where additional qualifications are conducted for special applications.

INSERT D (to Section 7.2.3 of Appendix 3.8A)

...the AWS D1.1 Structural Welding Code. The visual acceptance criteria shall be as defined in NCIG-01, "Visual Acceptance Criteria for Structural Welding of Nuclear Power Plants," Revision 2, EPRI NP-5380.

Aggregates - material shall conform to ASTM C 33 per ACI 349 par. 3.3. ASTM specification C 637 may apply where deemed necessary for radiation shielding. Limestone based aggregates should be considered for use in the floor of the reactor cavity for core concrete interaction concerns.

Admixtures - Admixtures conforming to applicable ASTM standards are acceptable when qualified by testing to verify required mix design.

Water shall conform to requirements of ACI 349 Section 3.4 and Section 3.8.4.6.1.1. Use of non-potable water shall be restricted in accordance with ACI 349 Section 3.4.3.

Reinforcing Steel - ASTM A615 Grade 60, Fy = 60,000 psi
or - ASTM A706 Fy = 60,000 psi

The use of welded splices and mechanical connections is addressed under Paragraph 12.14.3 of ACI 349. Mechanical reinforcing coupler devices may be used.

Epoxy coating of reinforcing shall be in accordance with ASTM A775 (ACI 318 paragraph 3.5.3.7).

9.2.2 STEEL

9.2.2.1 Structural Steel

Structural Shapes - ASTM-A36, Fy = 36,000 psi
additional material per ANSI/AISC N690 Section Q1.4.1
(excluding round & tubular shapes)

Structural Tubing - ASTM-A500 Grade B, Fy = 42,000 psi

Steel Plates - ASTM A240 Type 304L Stainless Steel/ASTM A36

9.2.2.2 Structural Bolts

Structural Bolts shall comply with ASTM material specifications identified in Section Q1.4.3 of the ANSI/AISC Standard N690 or other materials identified in the "Specification for Structural Bolting Using ASTM A325 or A490 Bolts" and A449. Bolts shall have nuts and washers as identified below:

- Bolts -- A193, A320, A325, A490, ~~etc.~~ A354 or A449
- Nuts, for A325 -- A194 Grade 2 or 2H nuts or A563 Grade C, C3, D, DH, or DH3,
- Nuts for A193, A320, A354, and A490 - A194 Grade 2H or A563 Grade DH or DH3.
- Washers -- F436 hardened steel washers.

High strength threaded rods such as A193 Grade B7 or A320 Grade L43 may be used in lieu of A325 bolts with qualifying documentation identifying the installation.

The inner face of the lower Primary Shield Wall will be provided with projecting reinforced concrete corbels to be used as the support bases for the Reactor Vessel steel support Columns. Corbels shall have symmetrical reinforcing in the top and bottom to resist the upward loads resulting from a potential ex-vessel steam explosion (Section 3.8.3.3.H).

Refer to Table 3.8A-1 for additional design loads that are applicable to the Primary Shield Wall.

10.4.2 CRANE WALL (SECONDARY SHIELD WALL)

10.4.2.1 Description

The Crane Wall is a reinforced concrete right cylinder with an inside diameter of 130 feet and height of 118'-3" from its base. The top elevation is at El. 210'-0". The Crane Wall is a minimum of four feet thick.

10.4.2.2 Design Requirements

The Crane Wall provides supports for the polar crane and protects the steel containment vessel from internal missiles. In addition to providing biological shielding for the coolant loop and equipment, the Crane Wall also provides structural support for pipe supports/restraints and platforms at various levels.

The design shall address the vertical alignment of the Crane Wall with the corresponding structure below the Containment Vessel and provides special construction tolerances, as necessary, to ensure potential misalignment is appropriately considered. The design also considers potential differential basemat settlement and the effect on the Crane Wall alignment.

10.4.2.3 Design Loads (Reference Section 3.8.3.3)

Refer to Table 3.8A-1 for additional loads that are applicable to the Crane Wall.

10.4.3 REFUELING CAVITY

10.4.3.1 Description

The Refueling Cavity is the reinforced concrete enclosure that provides a pool filled with borated water above the reactor vessel to facilitate the fuel handling operation without exceeding the acceptable level of radiation inside the Containment Vessel. The Refueling Cavity has the following sub-compartments.

- Storage Area for Upper Guide Structure
- Storage area for Core Support Barrel
- Refueling Canal

The Reactor Vessel flange is [redacted] sealed to the bottom of the Refueling Cavity to prevent leakage of refueling water into the reactor cavity. The Fuel Transfer Tube connects the Refueling Cavity to the Spent Fuel Pool. The shield walls that form the Refueling Cavity are a minimum of six feet thick.

Railroad service is provided at the east end of the building with the track running through the inside of the building in the north-south direction.

11.5.3 ELEVATIONS

Turbine Building elevations are ~~provided in Section 1.2.~~ reference elevations only.

11.5.4 CODES AND STANDARDS

The codes and standards applicable to Seismic Category II buildings shall be met.

11.5.5 LOADS

In addition to the minimum design loads requirements of Section 5.1 of this appendix, the following additional specific load requirements shall be met. Should conflicting values occur between this section and Section 5.1 of this appendix, the values specified in this section apply.

11.5.5.1 Dead Load (D)

The estimated weights for major equipment are listed in Table 3.8A-7.

11.5.5.2 Live Load (L)

The live loads are specified in Table 3.8A-8.

11.5.5.3 Temperature Loads (T_o)

The normal operating temperature within the building ranges from 40°F to 100°F. The ambient temperature range outside of the building shall be -10°F to 100°F (Section 5.1.1.5 of this appendix).

11.5.5.4 Seismic Loads (E')

The seismic accelerations shall be as specified in the Table 3.8A-9.

11.5.5.5 Pipe Loads

Where the piping loads are not known at the time of design, beams and girders are designed for a concentrated load applied at midspan as indicated below.

1. In areas where the main steam and steam generator feedwater lines are located, use the weight of the lines full of water.

2. In areas where large bore piping is heavily concentrated:

Girders (column to column)	55 kips
Primary beams (column to column)	45 kips
Secondary beams	30 kips

TABLE 3.8A-3

COMPONENT COOLING WATER HEAT EXCHANGER STRUCTURE

SSE ACCELERATIONS IN Gs

Elevation	Long Direction	Short Direction	Vertical
Roof	0.727 ~~0.654~~	~~0.966~~ ~~1.296~~ 1.218	0.690 ~~1.249~~
First Floor	0.574	0.892 ~~1.139~~	0.685 ~~1.234~~
Basemat	0.513	0.819 ~~1.025~~	0.676 ~~1.213~~

Ductility reinforcing requirements for concrete sections are provided in Section 6.0 of this appendix

1.0 OBJECTIVE AND SCOPE

This Appendix presents analysis results and typical main reinforcing design for thirteen selected areas of the System 80+ Seismic Category I Nuclear Island structure, the Diesel Fuel Storage Structure, Component Cooling Water Heat Exchanger Structure, and Component Cooling Water Tunnel using the criteria in Appendix 3.8A. Based on the general arrangement of major structural elements and components, the thirteen Nuclear Island areas are selected to provide representative design details for structural elements having both typical and unique design requirements. Design details for the steel containment are included in Section 3.8.2.

In addition to the evaluation of the thirteen areas, shear requirements have been calculated and capacities demonstrated for all major shear walls of the Nuclear Island.

The resulting design forces and moments presented in this Appendix are from use of a conservative envelope of design loads. Reinforcing details presented are typical details to develop the capacity required to envelope these forces and moments. The design review demonstrates that it is feasible to design and construct the structures as configured in the general arrangements presented in Chapter 1. The structural analysis report prepared by the COL Applicant, Section 3.8.4.5.3, will document that the final design details for the Nuclear Island structure meet the analysis and design criteria of Section 3.8. U

Design and analysis details of the Diesel Fuel Storage Structure, Component Cooling Water Heat Exchanger Structure and Component Cooling Water Tunnel are provided in Section 7.0 of this appendix.

2.0 DESCRIPTION OF THE NUCLEAR ISLAND CRITICAL AREAS

The location and description of the thirteen areas are identified in Table 3.8B-1. The areas are shown in Figure 3.8B-1, Sheets 1-5.

3.0 ANALYSIS METHODS

The Nuclear Island is analyzed to account for both global and local effects of design basis loads described in Appendix 3.8A.

The complete Nuclear Island is founded on a common basemat and is analyzed as a monolithic structure. A three dimensional finite element model of the Nuclear Island is developed and equivalent static global loading conditions are applied to the structure. These results are combined using the loading combinations identified in Section 5.2 of Appendix 3.8A. The global results from the three dimensional finite element model are combined with local analysis results to determine forces and moments for the design of the walls, columns and slabs.

The analysis methods are described in further detail in Appendix 3.8A, Section 6.1.

4.0 LOADS AND LOAD COMBINATIONS

The loads evaluated for the Nuclear Island are addressed in Appendix 3.8A, Section 5.1.

Area 1B

Shear (in-plane)	235 kips/ft
(out-of-plane)	24 kips/ft
Moment	130 ft-kips/ft
Axial (tension)	50 kips/ft
(compression)	205 kips/ft

The in-plane loads on area 1C are predominantly shear loads from the SSE. The in-plane forces are obtained from output computed by the application of these loads to the static three dimensional finite element model. The out-of-plane loads on the wall are predominantly from the accident temperature differential from a postulated Annulus Ventilation System failure. The out-of plane resultant forces and moments are determined by hand calculation.

The design forces and moments for Area 1C are:

Shear (in-plane)	200 kips/ft
(out-of-plane)	86 kips/ft
Moment (2 way bending)	402 ft-kips/ft
	118 ft-kips/ft
Axial (tension)	140 kips/ft
(compression)	250 kips/ft

5.1.5 TYPICAL REINFORCING DETAILS

Area 1A Wall Thickness 4 feet

#18 at 12" vertical steel each face
#18 at 12" horizontal steel each face
Shear ties not required

Area 1B Wall Thickness 4 feet

#14 at 12" vertical steel each face
#14 at 12" horizontal steel each face
Shear ties not required

Area 1C Wall Thickness 4 feet

#18 at 12" vertical steel each face
#14 at 12" horizontal steel each face
Shear ties - #5 horizontal ties at 12" x 12"

Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix.

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5.1.6 CONCLUSION

The Area 1 concrete section strengths determined from the criteria in Appendix 3.8A are sufficient to resist the design basis loads.

5.2 AREA 2 - EAST END WALL ADJACENT TO TURBINE BUILDING

5.2.1 DESCRIPTION OF AREA

Area 2 is a segment of the exterior wall at the East end of the Nuclear Island adjacent to the Turbine Building. The wall extends from the top of the basemat at elevation 50'+0" to the top of the roof at elevation 146'+0". The walls in this area are four feet thick. Out-of-plane lateral support is provided to the walls by the floor slabs on the interior of the structure. The wall is arranged and designed to function as a major structural shear wall in addition to providing protection for the safety related equipment.

5.2.2 GENERAL LOADS

The loads applicable to Area 2 are summarized in Appendix 3.8A, Table 3.8A-1. The out-of-plane passive soil pressure loads are the predominant loads. The Nuclear Island evaluation credits the passive soil pressure loads to resist sliding.

5.2.3 GOVERNING LOAD COMBINATIONS

Area 2

Shear	(in-plane)	4.1.2(a)
	(out-of-plane)	4.1.2(a)
Bending		4.1.2(a)
Axial	(tension)	4.1.2(a)
	(compression)	4.1.2(a)

5.2.4 ANALYSIS METHODS AND RESULTS

The Area 2 wall is analyzed as a structural shear wall. The in-plane forces are obtained from output computed by the application of these loads to the static three-dimensional finite element model. The out-of-plane loads on the wall are predominantly soil pressure loads with the effect of the SSE. The out-of plane resultant forces and moments are determined by local two dimensional frame models.

The design forces and moments for Area 2 are:

Shear	(in-plane)	219 ~~200~~ kips/ft
	(out-of-plane)	273 kips/ft

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Moment	910 ft-kips/ft
Axial (tension)	50 kips/ft
(compression)	277 kips/ft

5.2.5 TYPICAL REINFORCING DETAILS

Area 2 Wall Thickness 4 feet

#18 at 12" vertical steel, 2 layers each face (below elevation 90'+3")
#14 at 12" vertical steel, 2 layers each face (above elevation 90'+3")
#11 at 12" horizontal steel, 2 layers each face
Shear ties - #6 horizontal ties at 12" x 12"
Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix.

5.2.6 CONCLUSION

The Area 2 concrete section strengths determined from the criteria in Appendix 3.8A are sufficient to resist the design basis loads.

5.3 AREAS 3A AND 3B - EMERGENCY DIESEL ROOM INTERIOR AND EXTERIOR WALLS

5.3.1 DESCRIPTION OF AREA

Diesel generator areas exist on the north and south side of the Nuclear Annex. The interior wall is Area 3A and exterior wall is Area 3B.

Area 3A, the interior wall, extends from the top of the basemat at elevation 50'+0" to the top of the roof slab at elevation 91'+9". This four feet wall continues upward ending at the top of the roof slab at elevation 191'+0". The wall at Area 3A functions as an east-west structural shear wall.

Area 3B, the exterior wall, extends from the top to the basemat at elevation 50'+0" to the top of the roof slab at elevation 91'+9". This five feet exterior wall spans between the basemat and the roof slab. This wall also functions as an East-West shear wall.

5.3.2 GENERAL LOADS

The loads applicable to Area 3 are summarized in Appendix 3.8A, Table 3.8A-1. The predominant loads on the exterior wall are from the out-of-plane soil pressure loads. Passive soil pressure was considered in the design of the exterior walls. The Nuclear Island evaluation credits the passive soil pressure loads to resist sliding.

Construction crane loads are also considered on the exterior wall. Lateral bracing of the exterior wall is considered during construction due to the vertical span of the wall.

The design forces and moments for Area 3B are:

Shear	(in-plane)	253 kips/ft
	(out-of-plane)	218 kips/ft
Moment		1756 ft-kips/ft
Axial	(tension)	40 kips/ft
	(compression)	230 kips/ft

5.3.5 TYPICAL REINFORCING DETAILS

Area 3A Wall Thickness 4 feet

#14 at 12" vertical steel each face
#14 at 12" horizontal steel each face
Shear ties not required

Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix.

Area 3B Wall Thickness 5 feet

#18 at 12" vertical steel, 3 layers each face
#18 at 12" horizontal steel each face
Shear ties - #5 horizontal ties at 4" x 12"

5.3.6 CONCLUSION

The Area 3 concrete section strengths determined from the criteria in Appendix 3.8A are sufficient to resist the design basis loads.

The exterior wall requires lateral shoring during construction to withstand the potential overburden pressure loads from construction cranes.

5.4 AREAS 4, 5 AND 7 - CONTAINMENT PEDESTAL, DISH AND SUPPORT

5.4.1 DESCRIPTION OF AREA

This area comprises the primary structural components supporting the Steel Containment Vessel (SCV) and its internal structures. The SCV is supported by the pedestal and outer dish. The outer dish is supported by the lower crane wall, the pedestal, the floor slab at elevation 91'+9", and the radial walls.

This section addresses the design of these structural components, specifically described as follows:

Area 7 Pedestal - Solid mass of concrete below the SCV, above the basemat, centered under the SCV, nominally 66 feet in diameter.

The design forces and moments for Area 5C are:

Shear	(in-plane)	400 kips/ft
	(out-of-plane)	45 kips/ft
Moment		528 ft-kips/ft
Axial	(tension)	107 kips/ft
	(compression)	334 kips/ft

5.5.5 TYPICAL REINFORCING DETAILS

Area 5A Wall Thickness 4 feet

(MSVH area)

#18 at 12" vertical steel, 2 layers each face
#18 at 12" horizontal steel, 2 layers each face
Shear ties - #5 horizontal ties at 4" x 12"

Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix.

Area 5B Wall Thickness 4 feet

#18 at 12" vertical steel each face
#18 at 12" horizontal steel each face
Shear ties - #4 horizontal ties at 4" x 12"

Area 5C Wall Thickness 6 feet (Inside Shield Building from top of basemat to bottom of slab at elevation 70'+0")

#18 at 12" vertical steel, 2 layers each face
#18 at 12" horizontal steel, 2 layers each face
Shear ties - #4 horizontal ties at 4" x 12"

5.5.6 CONCLUSION

The Area 5 concrete section strengths determined from the criteria in Appendix 3.8A are sufficient to resist the design basis loads. It is feasible to design and construct the structural components considered. The assumptions envelope the given parameters so that the design presented is adequate for any specific site conditions, within those parameters.

The main steam line piping is assumed to be 32 inches in diameter. The main steam line anchor is assumed to have an 80 inch diameter bearing plate. A minimum separation of 6' 6" from the centerline of the main steam line to any other discontinuity such as a wall, slab, opening or other possible failure plane should be maintained.

Any separations less than 6'6" shall be analyzed and designed on a case by case basis. The 6'6" distance is the radius of the shear failure cone with the bearing plate assumed.

5.6.5 TYPICAL REINFORCING DETAILS

Area 8 Wall Thickness 3 feet

#18 at 12" vertical steel, 2 layers each face
#18 at 12" horizontal steel each face
Shear ties - #4 horizontal ties at 4" x 12"
Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix.

5.6.6 CONCLUSION

The Area 8 concrete section strengths determined from the criteria in Appendix 3.8A are sufficient to resist the design basis loads. It is feasible to design and construct the structural components considered. The assumptions envelope the given parameters so that the design presented is adequate for any specific site conditions, within those parameters.

5.7 AREA 9 - SPENT FUEL POOL WALL

5.7.1 DESCRIPTION OF AREA

Area 9 is the wall between the spent fuel pool and the refueling canal, at Elevation 104'+0" to 146'+0", Column line 17-18 @ Column line T. The wall provides a barrier to isolate the spent fuel pool from the fuel transfer canal to allow maintenance on the fuel transfer system. A weir gate in the wall is removed to transfer fuel between the spent fuel pool and the refueling canal.

5.7.2 GENERAL LOADS

The loads applicable to Area 9 are summarized in Appendix 3.8A, Table 3.8A-1. These loads include hydrodynamic and thermal loads from the spent fuel pool.

5.7.3 GOVERNING LOAD COMBINATIONS

Area 9

Shear	(in-plane)	4.1.2(d)
	(out-of-plane)	4.1.2(d)
Bending		4.1.2(d)
Axial	(tension)	4.1.2(d)
	(compression)	4.1.2(d)

5.7.4 ANALYSIS METHODS AND RESULTS

The in-plane loads on Area 9 are predominantly shear loads from the SSE. The in-plane forces and moments are obtained from the global static three-dimensional finite element model results.

Out-of-plane forces and moments are obtained by applying the out-of-plane loads to a local static three-dimensional finite element model of the wall. These forces are then considered in conjunction with the loads from the global finite element model results to determine design forces and moments for the wall.

Horizontal reinforcing is designed for the maximum out-of-plane bending about a vertical axis, due to local loads. Vertical reinforcing is designed for the maximum out-of-plane bending about a horizontal axis, due to local loads, combined with the maximum tension produced by global loads. Out-of-plane shear is determined by local analysis.

The predominant forces are out-of-plane shear and bending forces from the hydrostatic and inertial forces associated with the water in the spent fuel pool, including sloshing effects. Also significant are the thermal effects from the heat generated by spent fuel.

The design forces and moments for Area 9 are:

Shear (in-plane)	282 kips/ft
(out-of-plane)	179 kips/ft
Moment (2 way bending)	2704 ft-kips/ft
	4807 ft-kips/ft
Axial (tension)	80 kips/ft

5.7.5 TYPICAL REINFORCING DETAILS

Area around weir gate notch in wall controls.

Area 9 Wall Thickness 6 feet

#18 at 8" vertical steel, 2 layers each face
#18 at 6" horizontal steel, 3 layers each face
Shear ties - #5 horizontal ties at 18.5" x 6"

Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix. Y

5.7.6 CONCLUSIONS

The Area 9 concrete section strengths determined from the criteria in Appendix 3.8A are sufficient to resist the design basis loads. It is feasible to design and construct the structural components considered. The assumptions envelope the given parameters so that the design presented is adequate for any specific site conditions, within those parameters.

5.8.5 TYPICAL REINFORCING DETAILS

Area 10 Wall Thickness 5 feet

#18 at 12" vertical steel, 2 layers each face
#18 at 12" horizontal steel, 3 layers each face
Shear ties - 2 #5 horizontal ties at 4" x 12"
Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix.

5.8.6 CONCLUSION

The Area 10 concrete section strengths determined from the criteria in Appendix 3.8A are sufficient to resist the design basis loads. It is feasible to design and construct the structural components considered. The assumptions envelope the given parameters so that the design presented is adequate for any specific site conditions, within those parameters. To accommodate punching shear requirements, the anchor embedment design must incorporate excess punching shear, or alternately rupture loads may be reduced by more detailed analysis.

The main steam line piping is assumed to be 32 inches in diameter. The main steam line anchor is assumed to have an 80 inch diameter bearing plate. A minimum separation of 7'6" from the centerline of the main steam line to any other discontinuity such as a wall, slab, opening or other possible failure plane should be maintained. The main feedwater line located in this area is assumed to be 24 inches in diameter and contains a 72 inch diameter bearing plate. The minimum separation of the main feedwater centerline to the edge of any other discontinuity is 7'0".

Any separation less than 7'6" for the main steam lines and 7'0" for the main feedwater line is analyzed and designed on a case by case basis. These distances are the radii of the shear failure cones of the main steam line and main feedwater line with the bearing rings assumed.

5.9 AREA 11 - NORTH-WEST END WALL

5.9.1 DESCRIPTION OF AREA

Area 11 is the northern part of the west side end wall adjacent to the Radwaste Building. The wall extends from the top of the basemat at elevation 50' + 0", to the top of the roof in the Fuel Handling area at elevation 191' + 0". The walls in this area are four feet thick. Out-of-plane lateral support is provided to the walls by the floor slabs on the interior of the structure. The wall is arranged and designed to function as a major structural shear wall in addition to providing protection for the safety related equipment.

5.9.2 GENERAL LOADS

The loads applicable to Area 11 are summarized in Appendix 3.8A, Table 3.8A-1. The out-of-plane passive soil pressure loads are the predominant loads in the lower elevations of the wall. The Nuclear Island evaluation credits the passive soil pressure loads to resist sliding. Local loads resulting from the wall mounted supports for the spent fuel pool bridge crane are also included.

5.9.3 GOVERNING LOAD COMBINATIONS

Area 11

Shear	(in-plane)	4.1.2(a)
	(out-of-plane)	4.1.2(a)
Bending		4.1.2(a)
Axial	(tension)	4.1.2(a)
	(compression)	4.1.2(a)

5.9.4 ANALYSIS METHODS AND RESULTS

The Area 11 wall is analyzed as a structural shear wall. The in-plane forces are obtained from output computed by the application of these loads to the static three-dimensional finite element model. The out-of-plane loads on the wall are predominantly soil pressure loads with the effect of the SSE in the lower elevations. The effects of the spent fuel pool bridge crane loads in combination with thermal loads are predominant in the upper portion of the wall. The out-of plane resultant forces and moments are determined by local two dimensional frame models.

The wall is analyzed and designed to resist the spent fuel pool bridge crane bending and axial loads. The bending effects dissipate below elevation 91'+9".

The design forces and moments, excluding the spent fuel pool bridge crane loads, for Area 11 are:

Shear	(in-plane)	274 kips/ft
	(out-of-plane)	~~180~~ 183 kips/ft
Moment		938 ft-kips/ft
Axial	(tension)	240 kips/ft
	(compression)	512 kips/ft

5.9.5 TYPICAL REINFORCING DETAILS

Area 11 Main Steel

Wall Thickness 4 feet

#14 at 12" vertical steel ~~inside~~ 2 layers each face (above elevation 90'+3")
#18 at 12" vertical steel ~~outside~~ 2 layers each face (below elevation 90'+3")
#11 at 12" horizontal steel ~~each face~~ 2 layers each face

Shear ties - #5 horizontal ties at 12" x 12"

Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix.

5.11.4 ANALYSIS METHODS AND RESULTS

The Area 13 basemat responds in bending and shear loads from the SSE and dead load. The forces and moments are obtained from application of these loads to the static three-dimensional finite element model. The moment evaluated is the maximum moment experienced by the basemat. The shear evaluated is from a representative area under a primary shear wall. Most of the basemat will not require any shear reinforcing.

The design forces and moments for Area 13 are:

Moment:	3545 ft-kips/ft
Shear:	68.3 kips/ft

The basemat is symmetrically reinforced to resist the potential moments as a result of differential settlement of the foundation. The capacity of the basemat to withstand differential settlement is determined by calculating the deflection at the edge of the mat that would occur if the maximum moment were developed in the center. The maximum deflection in the basemat relative to the center of the Nuclear Island at the four exterior walls is:

Wall	Delta
North	20 in
South	20 in
East	25 in
West	49 in

5.11.5 TYPICAL REINFORCING DETAILS

Basemat Thickness 10 feet

#18 at 12" horizontal steel, 2 layers each face each direction

Shear ties - (When required)

#10 ~~horizontal~~ vertical ties at 12" x 12"

Most of the basemat will not require any shear reinforcing.
Additional ductility reinforcing shall be provided as described in Section 6.0 of this appendix.

5.11.6 CONCLUSIONS

The Area 13 concrete basemat strength determined from the criteria in Appendix 3.8A is sufficient to resist the design basis loads. It is feasible to design and construct the nuclear island foundation basemat. The design envelopes the given parameters so that the design presented is adequate for any specific site conditions, within those parameters. Stress concentrations exist in the areas around sumps that require additional detailed analyses and design.

Center Wall:

The primary flexural reinforcing for this two-foot thick wall consists of a rectangular grid of #11 at 6 inches each way/each face, [i.e., 3.12 in^2/ft].

No transverse shear reinforcing is required.

Roof:

The primary flexural reinforcing for these two-foot thick walls consists of a rectangular grid of #11 at 6 inches each way/each face [i.e., 3.12 in^2/ft].

No transverse shear reinforcing is required.

7.1.5 CONCLUSION

The concrete and reinforcing steel section strengths of the Diesel Fuel Storage Structure are sufficient to resist the design basis load and load combination criteria specified in Sections 3.8A.11.1 and 3.8A.5.0. Typical reinforcing details are shown in Figures 3.8B-5 and 3.8B-6.

7.2 COMPONENT COOLING WATER HEAT EXCHANGER STRUCTURE

7.2.1 DESCRIPTION OF STRUCTURE

The Component Cooling Water Heat Exchanger Structure is a single bay, partially embedded, two-story reinforced concrete building. The top floor houses two heat exchangers supported on saddles which spread the loadings to the supporting floor and column system.

The specified concrete compression strength is 4,000 psi and the specified minimum yield strength of the reinforcing steel is 60,000 psi.

7.2.2 ANALYSIS METHODS

The Component Cooling Water Heat Exchanger Structure is analyzed for the design loads described in Appendix 3.8A to determine the global and localized member forces for which the structure must be designed.

The structure is analyzed using manual computations which consider the structure to be comprised of linear elastic one-way wall and slab panels. Thermal and equivalent static loads corresponding to the various individual loading conditions identified in Sections 3.8A.5.1 and 3.8A.11.2.5 are applied to the one-way panel models and resulting member forces and moments computed. The resulting member forces are combined in accordance with the load combinations, specified in Section 5.2.2 of Appendix 3.8A, to determine the design loads for the critical sections.

No transverse shear reinforcing is required.

Floor Slab at Elevation 90'-9":

The primary reinforcing for the three-foot floor slab consists of a rectangular grid of #10 at 10 inches each way/each face, [i.e., 1.52 in^2/ft].

No transverse shear reinforcing is required.

Roof Slab at Elevation 110'-9":

The primary reinforcing for these two-foot thick roof consists of a rectangular grid of #11 at 10 inches each way/each face, [i.e., 1.87 in^2/ft].

No transverse shear reinforcing is required.

7.2.5 CONCLUSION

The concrete and reinforcing steel section strengths of the Component Cooling Water Heat Exchanger Structure are sufficient to resist the design basis load and load combination criteria specified in Sections 3.8A.11.2 and 3.8A.5.0. Typical reinforcing details are shown in Figures 3.8B-7 through 3.8B-9.

7.3 COMPONENT COOLING WATER TUNNEL

7.3.1 DESCRIPTION OF STRUCTURE

The Component Cooling Water Tunnel is a single compartment, fully embedded, one-story reinforced concrete structure. The tunnel houses and protects the Component Cooling Water piping which is routed from the corresponding Nuclear Island pipe chase to the basement of the Component Cooling Water Heat Exchanger Structure. The tunnel is attached at one end to the Nuclear Island Pipe Chase and the Component Cooling Water Heat Exchanger Structure at the other end via flexible connections. The flexible connections allow differential movement between the three structures without transferring loadings.

The specified concrete compression strength is 4,000 psi and the specified minimum yield strength of the reinforcing steel is 60,000 psi.

7.3.2 ANALYSIS METHODS

The Component Cooling Water Tunnel is analyzed for the design loads described in Appendix 3.8A to determine the global and localized member forces for which the structure must be designed.

The structure is analyzed using manual computations which consider the structure to be comprised of linear elastic one-way wall and slab panels. The lateral loads on the tunnel were evaluated using a linear elastic frame model with a unit width. Thermal and equivalent static loads corresponding to the various individual loading conditions identified in Sections 3.8A.5.1 and 3.8A.11.5 are applied to the equivalent frame model and resulting member forces and moments computed. .7 The resulting

North and South Walls:

The primary reinforcing for these two-foot thick walls consists of a rectangular grid of #11 at 10 inches each way/each face, [i.e., 1.87 in ^{2}/ft].

No transverse shear reinforcing is required.

Roof:

The primary reinforcing for these two-foot thick roof slabs consist of a rectangular grid of #11 at 10 inches each way/each face, [i.e., 1.87 in^2/ft].

No transverse shear reinforcing is required.

7.3.5 CONCLUSION

The concrete and reinforcing steel section strengths of the Component Cooling Water Tunnel are sufficient to resist the design basis load and load combination criteria specified in Sections 3.8A.11.7 and 3.8A.5.0. Typical reinforcing details are shown in Figures 3.8B-10 and 3.8B-11.

TABLE 3.8B-1

AREAS IDENTIFIED FOR DETAILED DESIGN

Area	Description	Section	Elevation	Col. Line/Azimuth
1	Shear & Shield Building Wall	1A	50 to ~~156~~ 115+6	D-F @ 17
		1B	50 to ~~115+6~~ 91+9	E17
		1C	50 to ~~158~~ 146	16-18, E-F
2	East Wall @ Turb Building	2	~~40~~ 50 to ~~93~~ 146	B14
3	Diesel Gen. Room Ext. & Int. Walls	3A	~~40~~ 50 to 93	N23
		3B	~~40~~ 50 to 93	N25
4	Subsphere Radial Wall	4	~~40~~ 50 to ~~52~~ 80+9	225°, R33-R65
5	Shear Wall and Slab @ Emerg. FDW Pump Room and CCW Pump Room	5A	~~40~~ 50 to ~~158~~ 156	K12-~~[illegible]~~
		5B	~~40~~ 50 to 130+6	K11
		5C	~~40~~ 50 to ~~158~~ 106	K10-K13
6	SCV Anchorage Region	6	70 to ~~92~~ 91+9	~~[illegible]~~ R76.5
7	SCV Support Pedestal	7	50 to 62	~~K33~~ K17 & R33
8	S/G Wing Wall @ IRWST	8	70 to 91+9	~~Along~~ L15
9	Spent Fuel Refueling Canal Wall	9	~~93~~ 104 to ~~117~~ 146	T17-18
10	Main Steam Valve House Wall	10	106 to 130	H23-25
11	Nuclear Annex Wall @ Radwaste Building	11	50 to ~~91+9~~ 191	U19-20
12	Interior Structure Steel Columns	12	91+9 to ~~115~~ 112	N/A
13	Basemat	13	40 to 50	N/A

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influence coefficients are calculated for each dynamic degree-of-freedom of each mass point and for each degree-of-freedom of each support point. The ANSYS computer code (Section 3.9.1.2.1.~~[illegible]~~) is also used as an alternate to MDC-STRUDL for defining the dynamic characteristics of the reactor coolant system and seismically analyzing it.

The program can perform either time-history analysis or spectrum analysis using the modal super position technique. Support reactions, member loads and joint acceleration are computed by back substituting from the modal coordinates to physical coordinates through the applicable transformation matrices and then combining modal contributions from each individual mode included in the response analysis.

MDC STRUDL is a program which is commercially available and has had sufficient use to justify its applicability and validity. Extensive verification of the C-E version has been performed to supplement the public documentation. The version of the program in use at C-E was developed by the McDonnell Automation Company/Engineering Computer International and is run on the IBM computer system. MDC STRUDL is described in more detail in Reference 1.

3.9.1.2.1.2 C-E MARC

The C-E MARC program is a general purpose nonlinear finite element program with structural and heat transfer capabilities. It is described in detail in Reference 2.

C-E MARC is used for stress analysis of regions of vessels, piping or supports which may deform plastically under prescribed loadings. It is also used for elastic analyses of complex geometries where the graphics capability enables a well defined solution. The thermal capabilities of C-E MARC are used for complex geometries where simplification of input and graphical output are preferred.

C-E MARC is the C-E modified version of the MARC program, which is commercially available and has had sufficient use to justify its applicability and validity. Extensive verification of the C-E version has been performed to supplement the public documentation.

3.9.1.2.1.3 PICEP

The PICEP program calculates the flow through a crack in a pipe. PICEP uses the simplified engineering approach for elastic-plastic fracture analysis for finding the crack opening displacement and area. Fluid calculation options include single and two-phase flow as well as allowance for friction. PICEP was developed by EPRI.

program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.10 CE105, Nozzle Fatigue Program

This program computes the redundant reactions forces, moments, and fatigue usage factors for nozzles in cylindrical shells.

This program is used to perform the fatigue analysis of reactor vessel nozzles and steam generator feedwater nozzle. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.11 CEC26, Edge Coefficients Program

This code calculates the coefficients for edge deformations of conical cylinders and tapered cylinders when subjected to axisymmetric unit shears and moments applied at the edges.

This program is used to perform the fatigue analysis of reactor vessel wall transition. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.12 CE124, Generalized 4 x 4 Program

This program computes the redundant reactions, forces, moments, stresses, and fatigue usage factors for the reactor vessel wall at the transition from a thick to thinner section and at the bottom head juncture.

This program is used to perform fatigue analysis of reactor vessel bottom head juncture. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

~~**3.9.1.2.1.13 SEC 11**~~

~~The SEC 11 program automates the flaw evaluation method of ASME B&PV, Section XI, Appendix A. This program performs the crack growth analyses and assesses the margin against critical crack size according to the criteria in Appendix A. The program has been verified by direct comparison of program results and hand calculations. The program is used for leak-before-break type analyses.~~

3.9.1.2.1.~~14~~ 13 ANSYS

ANSYS is a large-scale, general-purpose, finite element program for linear and nonlinear structural and thermal analysis. This program is commercially available. Additional descriptive information on this code is provided in Section 3.9.1.2.2.2. This program is used for numerous applications for all components in the areas of structural, fatigue, thermal and eigenvalue analysis. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~15~~14 CE301, The Structural Analysis for Partial Penetration Nozzles, Heater Tube Plug Welds, and the Water Level Boundary of the Pressurizer Shell Program

This program computes various analytical parameters, primary plus secondary stresses and stress intensities, peak stresses and stress intensities, and the cyclic fatigue analysis with usage factors at cuts of interest. This program is utilized to satisfy the requirements of Section III, of the ASME B&PV Code.

This program is used in the fatigue analysis of partial penetration nozzles in the pressurizer and piping. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~16~~15 CE223, Primary Structure Interaction Program

This code calculates redundant loads, stresses, and fatigue usage factors in the primary head, tubesheet, secondary shell, and stay cylinder for pressure and thermal loadings.

This program is used in the fatigue analysis of the steam generator primary structure. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~17~~16 CE362, Tube-To-Tubesheet Weld Program

This code performs a three body interaction analysis of the tube-to-tubesheet weld juncture. The code calculates primary, secondary, and peak stresses and computes range of stress and fatigue usage factors.

This program is used in the fatigue analysis of steam generator tube-to-tubesheet weld. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~18~~17 CE286, Support Skirt Loading Program

This code calculates the stresses in the conical support skirt of the steam generator for external loads.

This program is used in the structural analysis of steam generator support skirt. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~19~~ 18 CE210, Principal Stress Program

This code sums stresses for three load conditions and computes principal stress intensity, stress intensity range, and fatigue usage factor.

This program is used in the fatigue analysis of steam generator components. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~20~~ 19 CE211, Nozzle Load Resolution Program

This is a special purpose code, used to calculate stresses in nozzles produced by piping loads in combination with internal pressure.

This program is used in the fatigue analysis of steam generator nozzles. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~21~~ 20 KINI2100 Program

This is a general purpose finite difference heat transfer program. This program is used for steady-state and transient thermal analysis.

This program is used in numerous thermal relaxation analyses for all components. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~22~~ 21 CEFLASH-4A

This is a code used to calculate transient conditions resulting from a flow line rupture in a water/steam flow system. The program is used to calculate steam generator internal loadings following a postulated main steam line break.

This program is used in a steam line break accident structural analysis. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~23~~ 22 CRIBE

This is a one-dimensional, two-phase thermal hydraulic code, utilizing a momentum integral model of the secondary flow. This code was used to establish the recirculation ratio and fluid mass inventories as a function of power level. The code is commercially available and has had sufficient use to justify its applicability and validity. This program is used for determining steam generator performance. The program was verified by comparisons of program results and hand-calculated solutions of classical problems.

3.9.1.2.1.~~24~~23 FAST 2 Y

FAST2 is a computer code originated by Shelltech Associates for the analysis of vessel-nozzle intersections. It uses closed form asymptotic results for the solutions of the thin shell equations. FAST2 calculates stress and deflections of a cylindrical vessel or spherical head with a cylindrical pipe intersecting the vessel wall.

Vessel geometries are idealized as a horizontal cylinder on two saddle supports, a horizontal cantilevered cylinder fixed on the left end, or a horizontal cantilevered spherical head. Spherical heads are simply supported at their base such that all points at the base remain in a vertical plane. Radial expansion and local rotation is a function of the head stiffness and the stiffness of an attached cylindrical vessel which may be included in the model at the user's option.

The loading conditions available in FAST2 are nozzle loads, vessel end loads, internal pressure, and thermal loads. Nozzle loads are applied at the nozzle/vessel intersection. Shear loads are not considered. Vessel end loads are external landings applied at the right end of the vessel. Internal pressure can be applied to any combination of vessel and pipe. Thermal loads are uniform thermal expansion parameters for each portion of the defined model.

The code has the capability of modeling stiffening rings at either or both ends of a cylindrical vessel, and at the vessel/head junction for a spherical head. End caps or vessel heads on a cylindrical vessel may be modeled by stiffening rings representing the equivalent stiffness of the head or cap.

FAST2 has been used by Shelltech Associates in the development of WRC Bulletin No. 297.

3.9.1.2.1.~~25~~24 PC-PREPS Y

The evaluation and design of pipe support frames and baseplate is performed using PC-PREPS. PC-PREPS is a personal computer based, integrated pipe support analysis software package. It is interactive, menu-driven, with built-in structural analysis and graphics capability. The package is totally self-contained, except for a word processor used for the final calculation document production. All operations, including the finite element analysis, are performed on the personal computer.

PC-PREPS allows a pipe support analyst to prepare data, view associated graphics, and execute frame and baseplate analyses. It can automatically perform load combinations and convert loads computed with pipe stress software to the pipe support frame, and from the frame to any of the defined baseplate. The post-processing capabilities of PREPS include AISC and NF Code checks, maximum displacement checks, weld stress check, and local stress check.

PC-PREPS has been qualified by comparison to other software performing similar calculations and to manual calculations.

3.9.1.2.1.~~26~~25 LIDOP

The LIDOP program computes the local crush characteristics of a pipe section for use in the analysis of pipe motion and subsequent impact on structural targets or pipe rupture restraint structures.

The program will generate crush rigidities and deformation energies for pressurized or unpressurized piping in the following geometries:

A. Ring crush against flat rigid surface.

B. Indent or straight pipe against rigid cylinder.

C. 1.5D pipe elbow (extrados) against a flat rigid surface.

D. Pipe bend (extrados) against a flat rigid surface.

E. Indent of straight pipe against a rectangular block.

Both dynamic effects and material properties are considered in generation of the crush characteristics.

Unpressurized force-displacement and energy-displacement characteristics of pipe and elbows are generated from empirical equations which are based on experimental data. Pressurization effects, based on fluid displacement during deformation, are superimposed on the unpressurized characteristics. The overall dimensions of the contact area, where applicable, are generated by empirically corrected geometric relationships. Dynamic effects of elbows are empirically determined from an experimental comparison of static and dynamic impact of spheres. Dynamic effects of all other geometries and elbows in certain cases are based on the results of finite element computer simulations of rings impacting flat, rigid surfaces. The effects of material properties are determined from empirical relationships based on computer predictions.

3.9.1.2.1.~~27~~26 TIMHIS6

The TIMHIS6 program performs modal superposition time history analysis for lumped mass/stick models and response spectra calculations.

3.9.1.2.1.~~28~~ 27 RELAP5

RELAP5 is used to perform transient analysis of thermal-hydraulic systems with water as the fluid. RELAP5 uses a five equation two-phase flow continuity equations, two phasic momentum equations and an overall energy equation augmented by the requirement that one of the phases is assumed saturated. In this model, only two interphase constitutive relations are required, those for interphase drag and interphase mass exchange. Models are included for abrupt area changes, choking, mass transfer interphase drag, wall friction and branching.

The program requires numerical input data that completely describes the initial fluid conditions and geometry of the system being analyzed. The output consists of variables necessary to describe the transient state of the system being analyzed.

3.9.1.2.1.~~29~~ 28 REPIPE

REPIPE computes the loading time histories on a piping network based upon the results from computer program RELAP5 hydrodynamic analysis of the contained fluid. The RELAP5 time-varying pressure, momentum flux and energy states throughout a fluid system containing water, steam, and/or a two phase mixture are used as in input to the REPIPE program to produce time histories for input to the piping stress analysis program.

REPIPE distributes the RELAP5 control volume forces to the structural network nodes by a process based upon fluid momentum balance principle and newtons third law of motion. The output from REPIPE consists of dynamic loads on the pipe, organized into force vs time tables.

3.9.1.2.1.~~30~~ 29 CCN-318

CCN-318 is a computer program used to evaluate the design of rectangular cross section attachments on ASME Class 2 and 3 Piping following the requirements of ASME Code Case N-318. The program checks for Code Case limitations, calculates the required coefficients and then checks local stress in the pipe wall. In addition, it also evaluates the adequacy of fillet and partial penetration welds. The results of the analysis are compared to ASME Code Allowables.

3.9.1.2.1.~~31~~ 30 CCN-392

CCN-392 is a computer program used to evaluate the design of circular cross section attachments on ASME Class 2 and 3 piping following the requirements of ASME Code Case N-392. The program checks for code case limitations, calculates the required coefficients and then checks the local stress in the pipe wall. In addition, it also evaluates the adequacy of fillet and partial penetration welds. The results of the analysis are compared to ASME Code Allowables.

3.9.1.2.1.~~32~~ 31 **TRANS2A**

TRANS2A is a computer program which determines radial temperature distributions and gradients in a pipe wall experiencing fluid temperature excursions. TRANS2A determines these temperature distributions by solution of the unsteady one-dimensional axisymmetric heat transfer equation. For aid in Class 1 piping analysis values of the thermal gradients ΔT_1 and ΔT_2 and the average temperatures ($\overline{T_a}$ *and/or* $\overline{T_b}$) are calculated (and printed) in accordance with ASME BPVC Section III Article NB-3650. To be of more aid to the analyst in choosing values of the average and temperature gradient data to be input to the combined stress analysis, TRANS2A evaluates the actual histories of the thermal stress terms according to the equations of Section III, Article NB-3650 with as many as ten sets of stress indices and summarizes them in a table by extreme and time of occurrence.

The analyses performed for branch line breaks use the MDC STRUDL (Section 3.9.1.2.1.1) or ANSYS (Section 3.9.1.2.1.~~14~~ 13) code.

The resultant component and support reactions are specified, in combination with the appropriate normal operating and seismic reactions, for design verification by the methods discussed below and in Section 3.9.3.

The system or subsystem analysis used to establish, or confirm, loads which are specified for the design of components and supports is performed on an elastic basis.

When an elastic system analysis is employed to establish the loads which act on components and supports, elastic stress analysis methods are also used in the design calculations to evaluate the effects of the loads on the components and supports. In particular, inelastic methods such as plastic instability and limit analysis methods, as defined in Section III of the ASME Code, are not used in conjunction with an elastic system analysis. The RCS and its supports, which are analyzed using elastic methods, are shown in diagram form in Figure 3.9-1.

Inelastic methods of analysis are used in cases where it is deemed desirable and appropriate to permit significant local inelastic response. In these cases, if any, the system or subsystem analysis performed to establish the loads which act on components and component supports are modified to include the inelastic strain compatibility in the local regions of the components and component supports at which significant local inelastic response is permitted.

Inelastic methods defined in Section III of the ASME Code as plastic instability or limit analysis methods are not used.

3.9.1.4.1.1 Reactor Internals and CEDMs

See Sections 3.7.3.14 and 3.9.2.5.

3.9.1.4.1.2 Non-Code Items

The components not covered by the ASME Code but which are related to plant safety include:

A. Reactor Internal Structures (Class IS).

B. Fuel.

C. Control element drive mechanisms (CEDMs).

D. Control element assemblies (CEAs).

3.9.2.5 Dynamic System Analysis of the Reactor and CEDMs Under Faulted Conditions

Dynamic analyses are performed to determine blowdown loads and structural responses of the reactor core support, internals structures and fuel to postulated pipe break and SSE loadings and to verify the adequacy of their design.

Because of Leak-Before-Break arguments, all main RCS loop pipe breaks and all major primary branch line pipe breaks have been eliminated from consideration of dynamic effects. Internal blowdown loads due to breaks in small primary side pipes (6 inch diameter and less are considered in the design of the reactor internals. The loads due to these small pipe breaks are combined with the SSE loads by the SRSS method, and are found to represent less than a 10% increase in the SSE loads. Stress intensities for faulted conditions are governed by reactor vessel response motions from SSE and major secondary side branch line pipe breaks. Dynamic analyses are performed to determine the structural response of the Class CS and internal structures to assure that the criteria of Table 3.9-14 is achieved for the appropriate combination of pipe break and SSE loads.

3.9.3 ASME CODE CLASS 1, 2 AND 3 COMPONENTS, COMPONENT SUPPORTS AND CLASS CS CORE SUPPORT STRUCTURES

ASME B&PV Code Section III Class 1, 2 and 3 Piping and Components are designed and constructed in accordance with Section III of the ASME Boiler and Pressure Vessel Code and Code Case(s).

In accordance with ASME Code, a specification is provided for piping supports which defines the jurisdictional boundary for the NF portion of the piping support.

For equipment component supports, such as those for pumps and vessels, the supports are generally furnished by the manufacturer along with the equipment. The supports are designed and classified and meet ASME Code Section III, Subsection NF.

Welding activities shall be performed in accordance with the requirements of Section III of the ASME Code. Component supports shall be fabricated in accordance with the requirements of Subsection NF of Section III of the ASME Code, ~~and, in addition,~~ Visual weld acceptance criteria shall be per the Nuclear Construction Issue Group (NCIG) standard NCIG-01 (Reference 51). Welding activities for A500 Grade B tube steel shall be performed in accordance with the requirements of AWS D1.1, "Structural Welding Code," (Reference 52).

V

3.9.3.1.4 Piping and Piping Supports

Piping systems classified as ASME Code Section III Class 1, 2 or 3 are designed to maintain dimensional stability and functional integrity under design loadings expected to be experienced during a 60-year design life. The COL applicant will reconcile the as-built piping with the as-designed piping configurations.

INSERT 3.9.3.1.4

3.9.3.1.4.1 ASME Code Class 1

A. Piping

For ASME Code Class 1 piping, the combinations of design loadings are categorized with respect to service levels, identified as Level A, Level B, Level C, or Level D, as shown in Table 3.9-10. The design stress limits for each of the loading combinations are found in ASME B&PV Code, Section III, NB-3600.

B. Piping Supports

For pipe supports, the design loading combinations are presented in Tables 3.8-5 and 3.9-12. Pipe support members are designed to meet the requirements defined by ASME Code, Section III, Subsection NF. See Appendix 3.9A, Section 1.7.4, for a further discussion.

3.9.3.1.4.2 ASME Code Class 2 and 3

A. Piping

For ASME Code Class 2 and 3 piping the combinations of design and service loadings are categorized with respect to system service levels identified as Design, Level A, B, C and D as shown in Tables 3.9-11. The design stress limits for each of the loading combinations are found in ASME B&PV Code, Section III, NC/ND-3600.

B. Piping Supports

For pipe supports, the design and service loading combinations are presented in Tables 3.9-12. Pipe support members are designed to meet the requirements defined by ASME Code, Section III, Subsection NF. See Appendix 3.9A, Section 1.7.4, for a further discussion.

INSERT TO 3.9.3.1.4

The COL applicant will perform an as-built inspection of the pipe routing, location and orientation, the location, size, clearances and orientation of piping supports, and the location and weight of pipe mounted equipment. The inspection will be performed by reviewing the as-built drawings containing verification stamps, and by performing a visual inspectoin of the installed piping system. The piping configuration and component location, size, and orientation shall be within the tolerances specified in the certified as-built piping stress report. The tolerances to be used for reconciliation of the as-built piping system with the as-designed piping system are provided in Reference [redacted]. A reconciliation analysis using the as-built and as-designed information shall be performed. The certified as-built stress report shall document the results of the as-built reconciliation analysis.

53.

9 Component support building structures are designed to meet the criteria in Appendix 3.8A.

3.9.3.4 Component Supports

Jurisdictional boundaries between ASME Section III Class 1, 2 and 3 component supports and the building structure are established in accordance with ASME Section III, Subsection NF.

ASME B&PV Code Section III Class 1, 2 and 3 component supports are designed and constructed in accordance with Section III of the ASME B&PV Code and Code Case(s). V

INSERT B

Supports for ASME Section III Code Class 1, 2 and 3 components are specified for design in accordance with the loads and loading combinations discussed in Section 3.9.3.1 and presented in Table 3.9-2. Y

Component supports which are loaded during normal operation, seismic and following a pipe break (branch line breaks not eliminated by leak-before-break) are specified for design for loading combinations (A) through (D) of Section 3.9.3.1. Design stress limits applied in evaluating loading combinations (A), (B), and (C) of Section 3.9.3.1 are consistent with the ASME Code, Section III. The design stress limits applied in evaluating loading combination (D) of Section 3.9.3.1 are in accordance with the ASME B&PV Code, Section III. Loads in compression members are limited to 2/3 of the critical buckling load.

Concrete expansion anchors meet the requirements of ACI-349, "Code Requirements for Nuclear Safety Related Concrete Structures" and IE Bulletin 79-02, Rev. 02, "Pipe Support Base Plate Design Using Concrete Expansion Anchor Bolts", November 8, 1979, with the provisions identified in Section 3.8.4.5 and further discussed in Appendix 3.9A.

See Appendix 3.9A, Section 1.7.4, for a discussion of concrete expansion anchors.

Where required, snubber supports are used as shock arrestors for safety-related systems and components. Snubbers are used as structural supports during a dynamic event such as an earthquake or a pipe break, but during normal operation act as passive devices which accommodate normal expansions and contractions of the systems without resistance. For System 80+, snubbers are minimized, to the extent practical, through the use of design optimization procedures.

Assurance of snubber operability is provided by incorporating analytical, design, installation, in-service, and verification criteria. The elements of snubber operability assurance for System 80+ include:

A. Consideration of load cycles and travel that each snubber will experience during normal plant operating conditions.

INSERT B (to Section 3.9.3.4)

Seismic Category I component supports are designed to meet the requirements of Subsection NF, Section III of the ASME Code. Welding fabrication and installation, nondestructive examination (NDE) and acceptance standards shall be in accordance with Subsection NF, Section III of the ASME Code. In addition, visual weld acceptance criteria shall be per the Nuclear Construction Issue Group (NCIG) standard NCIG-01 (Reference 51).

Radiographic examinations will be accepted by the COL applicant's nondestructive examination (NDE) Level III examiner prior to final acceptance.

Confirmation that facility welding activities are in compliance with the certified design commitments shall include verifications of the following by individuals other than those who performed the activity:

1. Facility welding specifications and procedures meet the applicable ASME Code requrements,

2. Facility welding activities are performed in accordance with the applicable ASME Code requirements,

3. Welding activities related records are prepared, evaluated and maintained in accordance with the ASME requirements,

4. Welding processes used to weld dissimilar base metal and welding filler metal combinations are compatible for the intended applications,

5. The facility has established procedures for qualifications of welders and welding operators in accordance with the applicable ASME Code requirements,

6. Approved procedures are available and are used for pre-heating and post-heating of welds, and those procedures meet the applicable requirements of the ASME Code,

7. Completed welds are examined in accordance with the applicable examination method required by the ASME Code.

Y

43. "Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing," USNRC Regulatory Guide 1.20 Rev. 2, May, 1976.

44. "A Comprehensive Vibration Assessment Program for Palo Verde Nuclear Generating Station Unit 1 (System 80 Prototype)," Combustion Engineering, Inc., CEN-263, Rev. 1 January, 1985 (Proprietary).

45. "Structural Analysis of Fuel Assemblies for Seismic and Loss-of-Coolant Accident Loading," Combustion Engineering, Inc., CENPD-178, Revision 1, August 1981.

46. "Random Vibrations, Elementary Theory, Structural Dynamics and Design, Signal Analysis and Testing", University of Arizona Seminar, October 29 to November 2, 1990.

47. "Flow Induced Vibration", R. D. Blevins, Second Edition, 1990.

48. "ATWS: A Reappraisal, Part 3: Frequency of Anticipated Transients", EPRI-NP-2230, January 1982.

49. "Development of Transient Initiating Event Frequencies for Use in Probabilistic Risk Assessment", NUREG/CR-3862, May 1985.

50. NRC Letter of September 11, 1992, "Safety Evaluation on the Use of Single Earthquake Design for Systems, Structures and Components in the ABWR", Docket 52001.

51. NCIG-01 "Visual Weld Acceptance Criteria for Structural Welding of Nuclear Power Plants," Revision 2, EPRI NP-5380.

52. AWS D1.1, The American Welding Society, Structural Welding Code, 1990.

53. EPRI NP-5639, "Guidelines for Piping System Reconciliation," May 1988.

Replace with INSERT A1

TABLE 3.9-13

STRESS LIMITS FOR CEDM PRESSURE HOUSINGS

	Service Level ~~Operating Condition~~	Stress Categories and Limits of Stress Intensities (a)(b)
~~1.~~	~~Level A and Level B: Normal Operating Loading plus Normal Operating & Upset Plant Transients plus Safe Shutdown Earthquake (c) Forces.~~	~~Figures NB-3221-1 and 3222-1, including notes.~~
4. ~~2.~~	Level D: Normal Operating Loadings plus Faulted Plant Transients plus Safe Shutdown Earthquake Forces plus Loads due to Design Basis Pipe Breaks and/or pipe breaks not eliminated by LBB.	Article F-1000, Appendix F, Rules for Evaluation of Service Conditions Loading with Level D Service Limits.
5. ~~3.~~	Testing: Testing Plant Transients	Paragraph NB-3226

For the above listed operating conditions, the following limits regarding function apply:

1. Level A and Level B: The CEDMs are designed to function normally during and after exposure to these conditions.

2. Level D: For SSE plus Design Basis Pipe Breaks and/or pipe breaks not eliminated by LBB, the deflections of the CEDM pressure housing are limited to the elastic design limits of Article F-1330, Appendix F (defined above) so that the CEAs can be inserted after exposure to these conditions.

NOTE:

a. References listed are taken from Section III of the ASME Boiler and Pressure Vessel Code.

b. Dynamic loads including SSE, pipe breaks not eliminated by LBB and Design Basis Pipe Breaks are combined by the SRSS method in accordance with the guidelines of NUREG-0484.

c. Alternatively, a lower level of SSE motion may be used in accordance with Section 3.7.3.2.

INSERT A1 (Rev 2) to Table 3.9-13

1.	Design: Design Pressure, Weight, Other Sustained Mechanical Loads.	NB-3221 and Figure NB-3221-1, including notes.
2.	Level A: Normal Operating Loading plus Normal Operating Transients.	NB-3222 and Figure NB-3222-1, including notes.
3.	Level B: Normal Operating Loading plus Normal Operating & Upset Transients plus Low Cycle Fatigue Loading due to Safe Shutdown Earthquake (SSE)[c] Forces.	NB-3223 and Figures NB-3221-1 and NB-3222-1, including notes.

V

¶ Component support building structures are designed to meet the criteria in Appendix 3.8A.

attached to valve operators are also evaluated. The valve operator support does not support the pipe.

1.6.8 EXPANSION JOINT REQUIREMENTS

Expansion joints are evaluated to ensure compliance with vendor allowables based on the stress report provided by the vendor.

1.6.9 WELDING AND WELD ACCEPTANCE CRITERIA

Welding fabrication and installation, nondestructive examination (NDE) and acceptance standards for ASME Code Class 1, 2, and 3 piping shall be in accordance with Articles 4000 and 5000 of Subsections NB, NC, and ND in Section III of the ASME Code.

INSERT C

1.7 PIPE SUPPORT DESIGN REQUIREMENTS

1.7.1 GENERAL

Pipe supports are designed to meet the intended functional requirements of the stress analysis as well as the specified stress limits for the support components. Support components include typical structural steel members as well as manufactured catalog items for typical support components.

Supports are idealized in the piping analysis as providing restraint in the analyzed direction while providing unrestricted movement in the unrestrained direction. Since the design of supports cannot completely duplicate the idealized condition, supports are designed to minimize their effects on the piping analysis. Additionally, it is confirmed that the support design does not invalidate any assumptions used in the analysis of the piping system.

In addition to loads defined by the stress analysis, any additional forces the support are subjected to are considered in the support qualification.

1.7.2 DESIGN CONSIDERATIONS

1.7.2.1 Deadweight Loads

Gravity loads of the pipe are typically restrained by two types of supports. The piping analysis defines whether the support is designed as a rigid or flexible support. Flexible supports are specified when the pipe must be restrained for its gravity weight, however must remain free to move during thermal expansion. Vendor supplied spring components with specified spring constants are typically provided in this application.

INSERT C (to Section 1.6.9 of Appendix 3.9A)

Radiographic examinations will be accepted by the COL applicant's nondestructive examination (NDE) Level III examiner prior to final acceptance.

Confirmation that facility welding activities are in compliance with the certified design commitments shall include verifications of the following by individuals other than those who performed the activity:

1. Facility welding specifications and procedures meet the applicable ASME Code requrements,

2. Facility welding activities are performed in accordance with the applicable ASME Code requirements,

3. Welding activities related records are prepared, evaluated and maintained in accordance with the ASME requirements,

4. Welding processes used to weld dissimilar base metal and welding filler metal combinations are compatible for the intended applications,

5. The facility has established procedures for qualifications of welders and welding operators in accordance with the applicable ASME Code requirements,

6. Approved procedures are available and are used for pre-heating and post-heating of welds, and those procedures meet the applicable requirements of the ASME Code,

7. Completed welds are examined in accordance with the applicable examination method required by the ASME Code.

Welding activities involving non-ASME pressure retaining piping shall be accomplished in accordance with written procedures and shall meet the requirements of the ANSI B31.1 Code. The weld acceptance criteria shall be as defined for the applicable nondestructive examination method described in ANSI B31.1.

V

Welding activities of Seismic Category I pipe supports shall be as defined in Section 3.9.3.4.

induced into the pipe. Materials used as welded attachments are compatible with the piping material.

1.7.2.13 Minimum Design Loads

In order to provide some uniformity in load carrying ability, all supports are designed to minimum loads.

All supports are designed for the largest of the following three loads:

- 100% of the Level A condition load from the piping stress analysis
- The weight of a standard ANSI B31.1 span of water filled, schedule 80 pipe
- Minimum value of 150 pounds

1.7.3 LOAD COMBINATIONS

Load combinations are in accordance with Section 3.9.3.1 and are detailed in Table 3.9-12. For common supports, the SRSS method for combination of dynamic loads is used.

1.7.4 ACCEPTANCE CRITERIA

Pipe supports are either linear or plate and shell type devices. A linear type component support is defined as acting under essentially a single component of direct stress. Such devices may also be subjected to shear stresses. Plate and shell type of supports are fabricated from plate and shell elements and are normally subjected to a biaxial stress.

Seismic Category I pipe support members are designed to meet the requirements defined in ASME Code, Section III, Subsection NF. For A500 Grade B tube steel, NF requirements are supplemented by the weld requirements of AWS D1.1, "Structural Welding Code" (Reference 4.26). ~~Welding fabrication and installation, nondestructive examination (NDE) and acceptance standards shall be in accordance with Subsection NF, Section III of the ASME Code. In addition, visual weld acceptance criteria shall be per the Nuclear Construction Issue Group (NCIG) standard NCIG-01 (Reference 4.25).~~

moved to 3.9.3.4

Category II pipe support members are designed to meet the requirements of the AISC Steel Construction Manual.

Standard support manufactured catalog items are designed to meet the requirements of MSS-SP-58, "Pipe Hangers and Supports-Materials, Design and Manufacture." The application of catalog components is consistent with the manufacturer's requirements and are designed to meet the manufacturer's load rated capacities for the items. The piping design is consistent with the manufacturers' requirements for pipe deflection limits at pipe supports, such as requirements for travel in snubbers and hangers, or with industry practice, such as requirements for the

- snubbers, mechanical or hydraulic;
- constant or variable spring support hangers;
- rigid supports consisting of anchors, guides, restraints, rolling or sliding supports, and rod type hangers;
- sway braces and vibration dampeners;
- structural attachments such as ears, shoes, lugs, rings, clamps slings, straps and clevises;
- any other NRC approved devices.

Concrete expansion anchors are designed to meet the requirements of ACI-349, " Code Requirements for Nuclear Safety Related Concrete Structures", ~~with the following additional requirements and exceptions~~ as amended by Section 3.8.4.5.1.

~~A. A factor of safety acceptable to the NRC is applied to anchor allowables.~~

~~B. Provisions are taken for anchor strength reductions when the anchor is located in the concrete tension zone.~~
~~C. The failure cone angle used is consistent with recent test data for the specific application and acceptable to the NRC.~~

~~D. Embedment length calculations for ductile anchors demonstrate a minimum factor of safety of 1.5 when determining the pullout strength of the concrete based on the minimum tensile strength of the anchor steel.~~

~~E. The energy absorption capability (deformation capability after yield) is considered for the anchor material and an anchor acceptable to the NRC staff for ductile applications is chosen.~~

This assures that the design strength of concrete for a given expansion anchor or group of anchors is greater than the strength of the anchor steel, accounts for the effect of shear-tension interaction, and considers minimum edge distance and bolt spacing on expansion anchor capacity. Base plate flexibility is accounted for in the calculation of expansion anchor bolt loads.

1.7.5 JURISDICTIONAL BOUNDARIES

The jurisdictional boundaries are defined in ASME Section III, Subsection NF.

1.8 POSTULATED PIPE BREAKS

1.8.1 CLASSIFICATION

1.8.1.1 High Energy

High energy piping systems are those systems or portions of systems that are maintained pressurized at either temperatures in does not meet the LBB criteria of the PED, the COL applicant will revise the design until the LBB criteria of the PED are met.

Replace with INSERT 1.9.6.6

Reconciliation with as-built piping system parameters will also be made by the COL applicant by demonstrating (1) that the dimensional and material properties of each as-built piping system are consistent with the parameters used in the development of the PEDs and (2) that the as-built piping responses meet the ASME Code allowables and the LBB PED criteria.

1.10 TUBING

1.10.1 GENERAL

Design, analysis and loading considerations that are used for piping and supports are used for tubing. Due to the amount of tubing, bounding analyses are performed. This analysis method is also used for small-bore piping. These criteria apply to safety-related tubing.

Non-safety related manifold valves, solenoid valves, and instruments located over or near safety-related equipment or components are supported using the same criteria, except where justified by analysis. This prevents damage, degradation, or interference with the performance of equipment required for safety functions.

1.10.2 SUPPORT AND MOUNTING REQUIREMENTS

Two support mechanisms are used, free tube spans and tube track supports. Criteria for each tube support mechanism are determined as described above. The following are additional support and mounting considerations:

A. Tubing that is routed in two or more Seismic Category I structures (i.e., Reactor Building, Containment, Main Steam Valve House, Nuclear Annex, Diesel Generator Building) are verified to have sufficient flexibility to allow for differential building displacements.

B. Span lengths are chosen and supports and tube details are designed to accommodate heat tracing and/or insulation requirements.

C. All reservoirs, valves, and other in-line components are independently supported.

D. Movements of the root valve (SAM and TAM) between the pipe and the tubing are considered.

INSERT TO 1.9.6.6 OF 3.9A

Reconciliation of the as-built piping systems with the final design will be documented by the COL applicant in a LBB Evaluation Report. The LBB Evaluation Report shall contain results of the LBB evaluations for as-built piping. The LBB evaluations shall employ methods described in Section 1.9 of this appendix. Reconciliation of each as-built piping system qualified for LBB will be made by the COL applicant by demonstrating that:

(1) the as-built piping system meets the screening criteria of Section 3.6.3,

(2) the dimensional and material properties of the as-built piping system are consistent with the parameters used in the development of the final LBB PED(s) for that piping system,

(3) the as-built piping responses meet the ASME Code allowables and the final LBB PED criteria.

Editorial

3.10.2 SEISMIC AND DYNAMIC QUALIFICATION OF ELECTRICAL EQUIPMENT

Instrumentation and electrical equipment used for post-accident monitoring, the Reactor Protective System (RPS), the Engineered Safety Features Actuation System (ESFAS), the actuation devices for ESF system actuated components, and the emergency power system are designed to Seismic Category I requirements to ensure the ability to initiate required protective actions during, and following, a Safe Shutdown Earthquake (SSE) and for all static and dynamic loads from normal, transient and accident conditions; and, to supply power, following an SSE and for all static and dynamic loads from normal, transient and accident conditions, to components required to mitigate the consequences of events which require safety system operation.

Instrumentation and electrical equipment designated Seismic Category II are shown to maintain their structural integrity and not adversely impact safety related equipment during an SSE and for all static and dynamic loads from normal, transient and accident conditions.

1.100

Methods and procedures for qualifying electrical equipment and instrumentation are described below, and meet the requirements of Regulatory Guide ~~1.1.00~~, Revision 2, and IEEE Standard 344-1987.

3.10.2.1 Methods and Procedures for Qualifying Seismic Category I Electrical Equipment and Instrumentation

Seismic Category I instrumentation and electrical equipment required to perform a safety action during a seismic event and for all static and dynamic loads from normal, transient and accident conditions; after a seismic event and for all static and dynamic loads from normal, transient and accident conditions; or both are qualified with appropriate documentation in accordance with the requirements of the equipment specifications. These requirements are consistent with those of IEEE Standard 344-1987, "Seismic Qualification of Class 1 Electrical Equipment for Nuclear Power Generating Stations", and Regulatory Guide 1.100, Rev. 2. The methods and procedures used for qualifying Seismic Category I electrical equipment and instrumentation include the following:

A. Testing and analyses are used to confirm the operability of the instrumentation and electrical equipment during and after an SSE and for all static and dynamic loads from normal, transient, and accident conditions. Prior to SSE qualification, it is demonstrated that the equipment can withstand the application of five (5) cycles of 1/2 SSE excitations without loss of structural integrity. Analyses alone, without testing, is used as a basis for qualification only if the necessary functional operability of the

ATTACHMENT 12

TABLE 1.8-6

(Sheet 1 of 2)

SYSTEM 80+ INDUSTRIAL CODES AND STANDARDS

Code	Edition	Title
ANSI/American Concrete Institute [ACI]		
318	1989	Building Code Requirements for Reinforced Concrete, 1991 Printing
349	1985	Code Requirements for Nuclear Safety-Related Concrete Structures
ANSI/American Institute of Steel Construction [AISC]		
N690	1984	Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities
	1989	Manual of Steel Construction, Allowable Stress Design, Ninth Edition
ANSI/American Nuclear Society [ANS]		
51.1	1983	Nuclear Safety Criteria for the Design of Stationary PWR Plants
56.2	1989	Containment Isolation Provisions for Fluid Systems after a LOCA
58.1	1982	Plant Design Against Missiles
58.2	1988	Design Basis for Protection of LWRs against Effects of Pipe Rupture
58.8	1984	Time Response Design Criteria for Safety-Related Operator Action
58.9	1987	Single Failure Criteria for LWR Safety Related Fluid Systems
ANSI/American Petroleum Institute [API]		
650	1988	Welded Steel Tanks for Oil Storage
ANSI/American Society of Civil Engineers		
7	1990	Minimum Design Loads for Building and Other Structures [ANSI A58.1]
ANSI/American Society of Mechanical Engineers [ASME]		
BPVC	1989	Section II; Materials Specifications
BPVC	1989	Section III; Rules for Construction of Nuclear Power Plant Components; Division I, Division II
BPVC	1989	Section V, Non-Destructive Examination
BPVC	1989	Section VIII; Rules for Construction of Pressure Vessels
BPVC	1989	Section IX; Qualification Standard for Welding and Brazing
BPVC	1989	Section XI; Rules for Inservice Inspection of Nuclear Power Plant Components; Editions and Addenda As Applicable
AG-1	1991	Code on Nuclear Air and Gas Treatment
B31.1	1992	Power Piping
OM-S/G	1990	Standards and Guides for Operation and Maintenance of Nuclear Power Plants; through 1992 Addenda.
NQA-1	1989	Quality Assurance Program Requirements for Nuclear Facilities, and NQA-1b-1991 Addenda
NQA-2	1989	Quality Assurance Requirements for Nuclear Power Plants, and NQA-2a-1990 Addenda

Pressure Level	Internal Pressure (psia)	Failure Probability
Design	68	0.00
1.5 x Design	94	0.00
ASME Level "C" (Local 3D)	145-135	0.03
ASME Level "C" (Global)	157-147	0.05
Nominal Yield (mean properties)	172-160	0.50
Maximum Yield (max. properties)	187-174	1.00

This method was used to translate data obtained from containment stress analyses to fragility (probabilistic failure) curves at temperatures typical of both early and late containment failure. It was assumed that early failure stress curves allow greater strength because of the lower shell temperatures expected prior to containment failure. In these instances, containment failure is due to a rapid pressurization process to which the shell cannot thermally respond. The design basis accident (DBA) peak temperature (290°F) was selected as the conservative temperature for evaluation of the early containment failure.

Late containment failure includes a gradual overpressurization process that takes from hours to days; therefore, failure is expected to occur with a "hot" wall. The late containment failure fragility curve for "wet" sequences was conservatively established assuming the 350°F peak containment environmental temperature. The dry cavity overpressurization scenario was a conservative upper bound of the median shell temperature (See Section 19.11.5).

The fragility curve generated using the pressure-failure probability points of the above table are shown in Figure 19.11.3.1-3 for a containment environmental temperature of 290°F. This curve is conservatively biased in the low pressure tail of the curve and consequently results in a modestly conservative bias within the PRA. This is confirmed by comparison of the piecewise linear fragility curve developed in this section with alternate methodologies employing a lognormal containment fragility curve construction. (See, for example, Reference 111).

(See Appendix 19.11H)

APPENDIX 19.11H

COMMENTS ON THE CONSTRUCTION AND APPLICATION OF THE SYSTEM 80+ CONTAINMENT FRAGILITY CURVE

Introduction

The construction of the containment fragility curve used in the PRA is described in Section 19.11.3.1.2.4. The construction is based on general guidance used in the support of NUREG-1150. In estimating failure, it was assumed that once the material yield point is reached using an axisymmetric shell model described in Section 19.11.3.1.2.3.1 and 19.11.3.1.2.3.2, the containment will fail.

The above procedure has been biased to provide a conservative estimate of the containment failure probability. This conservative bias arises from the following assumptions / procedures:

1. All properties are evaluated at high mean shell temperatures. In fact, it is expected that during most containment challenges to which the fragility curve is applied the average containment shell temperature will be between 150 F and 250 F. This temperature range is based on the fact that the PRA containment challenges with sprays operational will maintain a cool containment atmosphere. For those transients where sprays are unavailable, the shell temperature prior to burn will be less than 250 F to ensure the containment atmosphere is not inerted. While burn temperatures can be high, their short duration (less than 30 seconds) and the large mass of the steel shell results in only minor increases in the mean shell temperature. This assumption conservatively biases the median containment strength calculation from 2 to 10%.

2. In the fragility curve construction, the median material yield stress was taken to be 1.10 times the minimum expected yield stress. Material data discussed in Reference 210 of CESSAR-DC indicates that the median shell stress is actually 1.167 times the minimum yield stress. The difference between these values was taken to approximately account for effects of material variations and modeling uncertainties.

3. The fragility curve used in the PRA assumed a linear fit between the points defined in the Table in Section 19.11.3.1.2.4 [redacted]. This procedure overestimated the failure probability of the shell in the tail region of the fragility curve below the 3% failure point (in the pressure region between 94 and 145 psia). The fragility curve challenges for System 80+ were mostly confined to containment pressure below 145 psia. The highest containment challenge noted for the very low probability high pressure DCH event resulted in a pressure of 151 psia, See Figure 19.11.4.1.1.-4A.

Comparison of C-E Fragility Curve with the Methodology of Reference 1

An alternate method of defining a fragility curve may be established by defining a logarithmic standard deviation for material properties and for modeling uncertainty. Given a failure pressure calculated from mean material properties a mean failure pressure probability curve can be developed. The methodology is generally analogous to the seismic strength analysis employed in Section 19.7.5. For the ultimate pressure fragility curve, the true mean containment failure pressure which results in the nominal

pressure (@ 290 F) based on the Reference 210 data would be 180.7 psia (166 psig). The beta factor based on the variation in the material yield point is .09. Material uncertainty in this range is typically consistent for fragility analyses. In order to account for other undefined property variations which are associated with the imperfect experimental modeling of a real structure (variations in plate thickness, boundary conditions, welds, residual stresses, etc.) the material uncertainty is combined with a second factor of equal value (.09). This factor is equivalent to the Δ parameter of Reference 1. This selection conservatively bounds the value of .05 used in that reference for this parameter. In addition, Reference 1 also suggests the use of a modeling uncertainty of .05 for a spherical shell geometry (see Reference 1, page 57). This selection is typically associated with the use of simplified Reference 1 modeling equation 5.81. Calculations of yield stresses used in the System 80+ ~~calculation~~ analyses were based on use of the ANSYS computer code. Therefore, the variability factor is not considered applicable, but was retained for conservatism. (In fact, Reference 1 indicates that ANSYS calcualtions tend to underpredict structural capability by approximately 10%. This bias, as well as, bias associated with the high temperature material property selection provides additional conservatism which is not reflected in the above statistical treatment.)

Following the procedure indentified in Reference 1, a combined coefficient of variation, β, for the spherical shell model was found to be:

$$\beta^2 = (.09)^2 + (.09)^2 + (.05)^2$$

and $\beta = 0.137$

For illustration purposes a combined standard deviation of .135 was selected for evaluating the fragility curve.

Assuming the fragility curve to be a lognormal distribution, the coefficient of variation, β, is

$$\beta = \ln (P_m/P_x) / K_x$$

A fragility curve explicitly accounting for material and modeling uncertainties can be then be evaluated as follows:

$$P_x = P_m \exp (- K_x \beta)$$

where

P_x :pressure with x probability of containment failure

P_m :~~mean~~ median failure pressure

K_x :coefficient associated with x probability of containment failure

β : combined standard deviation

The results of this curve construction and the data used for the System 80+ PRA fragility estimates are presented in Table 19.11H-1.

Table 19.11H-1: Comparison of Estimated Fragility Curve Methods		
Probability of Failure	Linear Approximation used in System 80+ PRA Pressure (psia)	Combined Beta Method Pressure (psia)
0.00	94	---
0.001	95.2	124
0.005	100	130.9
0.01	106	135.8
0.02	125	138.5
0.03	145	143.4
0.05	157	147.5
0.10	158	154.1
0.25	163.6	166.09
0.50	172	180.7

Using the current PRA values, the failure probability is significantly exaggerated in the low pressure region below 140 psia. Both methods yield similar results around 145 psia. In the pressure range from 145 to about 160 psia failure probabilities computed using the beta method are somewhat higher than that used for the PRA.

A review of these differences illustrates that for the region the fragility below about 145 psia, the net consequence of the use of the System 80+ PRA curve is to conservatively bias the overall shell failure probability. As will be discussed below. Containment fragility curves are used in evaluating three containment threats: hydrogen burn, DCH, and rapid steam generation.

Impact on Hydrogen Burn Failure Potential

Hydrogen Burn failure probabilities are shown in Tables 19.11.4.1.3-3 and 19.11.4.2.4-1. For early hydrogen burns the largest expected pressure threat was estimated to be below 106 psia. This was classified as having a containment failure probability of .006. Using the beta method, the probability is virtually zero.

A review of the late hydrogen burn sequences produce similar conclusions. The late hydrogen burn pressures range are defined for three cases as, 103, 125.2, and 140 psia. This results in containment failure probabilities of .006, .0184, and .0276. Using the beta method, the failure probabilities would be lower for the first two cases (less than .001) and about the same for case 3.

Impact on DCH Containment Failure Potential

The DCH containment threat is evaluated in Section 19.11.4.1. Figures 19.11.4.1.1-4 (a through c) illustrate the use of the fragility curves and bounding pressures used in the quantification process. For all DCH events that result from an intermediate pressure RV failure, the largest containment threat is below 120 psia, and therefore use of the existing PRA model results in fragility estimates that are consistently biased high. For the high pressure RV DCH, containment pressure threats are distributed between 99 and 151 psia. Of those threats fewer than 2% are above 145 psia. The net effect on using the existing PRA approach would produce higher DCH conditional containment failure probabilities than that using a beta approach.

Impact on Rapid Steam Generation

Rapid steam generation issues are discussed in Section 19.11.4.1.2. Table 19.11.4.1.2-4 indicates that the highest containment threat is 98 psia. This produces a small conditional containment probability using the existing fragility curve. The beta developed curve would indicate this failure probability to be zero.

Reference

1. NUREG/CR-2442,"Reliability Analysis of Steel Containment Strength", Greimann,L.G., et. al., Ames Laboratory, June, 1982

ATTACHMENT 13