November 29, 1996

ORGANIZATION: Baltimore Gas and Electric

SUBJECT: SUMMARY OF MEETING WITH BALTIMORE GAS AND ELECTRIC COMPANY (BGE) ON BGE LICENSE RENEWAL ACTIVITIES

On October 10, 1996, the Nuclear Regulatory Commission (NRC) staff met with representatives of BGE in Rockville, Maryland. The purpose of the meeting was BGE to deliver and discuss sample revisions to portions of the Structures, Component Supports, and Main Feedwater System integrated plant assessment (IPA) reports. A list of meeting attendees is provided in Attachment 1. Attachment 2 is a copy of the materials distributed during the meeting.

The IPA report revisions delivered during the meeting were intended to demonstrate BGE's implementation of the template as modified by the agreements in principle discussed at the September 11, 1996, management meeting. BGE stated that the reports were revised to address scoping and intended functions (Sections I. A and B of the template). The staff stated that it will visit Calvert Cliffs on October 17, 1996, to review onsite information related to BGE's scoping process, and will provide comments on the sample revisions on October 24, 1996. During the meeting, BGE also provided an overview of its scoping and screening process.

Prior to the public meeting, the staff met with BGE to gather information and obtain a better understanding of the Calvert Cliffs piping design and analysis process. Attachment 3 is a copy of the piping design information received by the staff. Attachment 4 is a copy of background information BGE provided to the staff in preparation for an upcoming meeting on BGE's license renewal activities for EQ and Non-EQ Cables. The meeting is scheduled for October 16, 1996.

Original signed by:
Scott C. Flanders, Project Manager
License Renewal Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Docket Nos.: 50-317&50-318

Attachments:
1. Attendance List
2. Meeting Handouts
3. Piping design information
4. BGE's license renewal activities for EQ and Non-EQ Cables

DF01

cc w/attachments:
Service List (with all enclosures)

Distribution: See page 2

DOCUMENT NAME: A:1010MS (SFlanders Disk)

To receive a copy of this document, indicate in the box: "C" = Copy without attachment/enclosure "E" = Copy with attachment/enclosure "N" = No copy

050026

OFFICE	PM:PDLR E	D:PDLR		
NAME	SFlanders	SFNewberry		
DATE	12/3/96	12/3/96		

RECORD COPY

HARD COPY:
Docket or Central File
PUBLIC
PDLR R/F
OGC
ACRS

DISTRIBUTION via e-mail
FMiraglia/AThadani (A) (FJM)/(ACT)
HBWang (HXW1)
RCorreia (RPC)
RZimmerman (RPZ)
JMoulton (JPM1)
SHoffman (STH)
RWessman (RHW)
TMartin (TTM)
PTKuo (PTK)
RAnand (RKA)
JStrosnider (JRS2)
DMatthews (DBM)
SLee (SSL1)
WDean (WMD)
SDroggitis (SCD)
SNewberry (SFN)
BPrato (RJP2)
JMitchell (JAM)
SPeterson (SRP)
SFlanders (SCF)
CRegan (CMR1)
LDoerflein (LTD)
GLainas (GCL)
EJordan (JKR)
PShemanski (PCS)
JSStewart (JSS1)
TSpeis (TPS)
JMoore/EHoller (JEM)/(EJH)
GMizuno (GSM)
GHolahan (GMH)
BSheron (BWS)

ATTENDANCE LIST
NRC MEETING WITH BALTIMORE GAS AND ELECTRIC
October 10, 1996

	NAME	ORGANIZATION
1.	Scott Flanders	NRC/NRR
2.	John Moulton	NRC/NRR
3.	P.T. Kuo	NRC/NRR
4.	Sam Lee	NRC/NRR
5.	Dennis DiBello	BGE/LCMU
6.	Marc Hotchkiss	ABB-CE (BGE/LCMU)
7.	Tricia Heroux	for EPRI
8.	A. Mimaki	MHI
9.	C. Negin	OAK TECHNOLOGIES
10.	Ikuo Morimaka	KANSAI ELECTRIC POWER
11.	S. Azumi	KANSAI ELECTRIC POWER
12.	T. Nishimoto	INTERNATIONAL ACCESS CORP.
13.	Don Shaw	BGE/LCMU
14.	Barth Doroshuk	BGE/LCMU
15.	Marv Bowman	BGE/LCMU
16.	Barry Tilden	BGE/LCMU

ATTACHMENT 1

BGE Deliverables to NRC

October 10, 1996

1. Feedwater System License Renewal Technical Report, written for LR Technical Report Template parts I.A. and B.

2. Structures License Renewal Technical Report, written for LR Technical Report Template parts I.A. and B.

3. Component Supports License Renewal Technical Report, written for LR Technical Report Template parts I.A. and B.

5.8 FEEDWATER SYSTEM

5.8.1 Scoping

System Description

The Condensate and Feedwater Systems are designed to provide a means for transferring the condensate from the condenser hotwell to the steam generators. The system design features provide for raising the temperature and pressure of the condensate, controlling the rate of flow to the steam generators, and the addition of chemicals and purification of the condensate. [UFSAR Ch. 10.2]

Condensate from the hotwells is pumped by motor-driven condensate pumps through the gland steam condenser, the condensate demineralizer and precoat filtering system, and the lowest feedwater heating stages to the suction of the condensate booster pumps. These booster pumps deliver the condensate to the two turbine-driven steam generator feed pumps (SGFPs) through two parallel sets of feedwater heaters. The SGFPs pump the feedwater through two parallel high pressure heaters to the steam generators. The condensed steam from the lower pressure feedwater heating stages drains back to the condenser hotwell and from higher pressure heaters is pumped into the condensate system. The Updated Final Safety Analysis Report (UFSAR) Chapter 10 includes a system description and diagram of the condensate and feedwater systems. Specific component design data is included in Table 10-1 of the UFSAR. [UFSAR Ch. 10.2]

A portion of the condensate flowstream is normally routed through the precoat filters and condensate demineralizers (full flow capability exists) in order to remove particulates and corrosive elements. Additionally, chemicals are added to the condensate for oxygen scavenging and pH control. [UFSAR Ch. 10.2, Sys Desc 32]

The portion of the Condensate System within the scope of License Renewal is addressed in section 5.6 of this application.

The Feedwater System includes the equipment, instruments and controls from the suction of the SGFPs, through the feedwater heaters, the regulating valves, the flow nozzles, the feedwater isolation valves, and the feedwater header check valves to the steam generator feedwater inlet nozzles. Also included are steam generator secondary side pressure and level instrumentation loops. This instrumentation provides steam generator level control information as well as the protective functions of steam generator isolation and auxiliary feedwater initiation. The steam generator vessels (including the feedwater nozzles) are included in the Reactor Coolant System, which is addressed in section 4.1 of this application. [FW AMR]

The Feedwater System functional requirements are determined by the System and Structure Scoping activity of the Integrated Plant Assessment (IPA) process described in the CCNPP IPA Methodology. The system functional requirements are: [SLSR]

- to transfer feedwater from the steam generator feed pump suction to the steam generators
- to regulate the flow of feedwater to the steam generators to maintain a constant water level
- to provide a means of raising the temperature of the condensate received by the feed pumps
- to provide a means for injecting chemicals into the steam generators from the chemical addition system

The Feedwater System is in scope for license renewal based on §54.4(a). In accordance with section 4.1.1 of the CCNPP IPA Methodology, a detailed list of system intended functions was determined.

The following Feedwater System intended functions were determined based on the requirements of §54.4(a)(1) and (2): [SLSR, FW CLSR]

- Provide containment overpressure protection
- Prevent reverse flow from the steam generator

- Send signals to the Engineered Safety Features Actuation System
- Provide signals to the Reactor Protection System
- Provide Signals to Auxiliary Feedwater Actuation System
- Isolate feedwater flow to the affected steam generator
- Provide a pressure retaining boundary for the system
- Maintain electrical continuity and provide fault protection for the plant safety related electrical system

All components of the Feedwater System that support the intended functions listed above are safety related, Seismic Category 1 and are subject to the applicable loading conditions identified in the UFSAR Section 5A.3.2 for Seismic Category 1 systems and equipment design.

The following Feedwater System intended functions were determined based on the requirements of §54.4(a)(3): [SLSR, FW CLSR]

- For fire protection (§50.48) - Monitor steam generator level to support safe shutdown in the event of a postulated severe fire.
- For environmental qualification (§50.49) - Maintain functionality of electrical equipment as addressed by the Environmental Qualification Program, and provide information used to assess the plant and environs condition during and following an accident.
- For anticipated transient without scram (§50.62) - Provide Auxiliary Feedwater Actuation System start signal (diverse from Reactor Protection System) on low steam generator water level conditions indicative of an Anticipated Transient Without Scram (Auxiliary Feedwater Actuation System).
- For station blackout (§50.63) - Provide steam generator level indication.

The regulations listed in §54.4(a)(3) do not necessarily require nuclear safety grade SCs in order to respond to the requirements of the regulations. However, the components of the Feedwater System that support the intended functions listed above associated with these regulations are safety related, Siesmic Category 1 and are subject to the applicable loading conditions identified in the UFSAR Section 5A.3.2 for Seismic Category 1 systems and equipment design.

<u>Scoped SCs and Their Intended Functions</u>

The components of the Feedwater System were reviewed and those that supported the system intended functions were determined to be within the scope of review for license renewal. The portion of the Feedwater System that is in scope includes all components (electrical, mechanical, and instrument) from the inlet side of the feedwater isolation motor-operated valve (MOV) to the steam generator nozzle. Also included are steam generator secondary side water level and pressure instrumentation loops, including the root isolation valves and all downstream components (valves, tubing, instruments). Figure 5.8-1 provides a simplified diagram of the feedwater system indicating the portion of the system within the scope of license renewal. This diagram is provided for illustration purposes only.

Several component types are common to many plant systems and perform the same passive intended functions. These are addressed separately in commodity evaluations and are not included in this section. The following identifies the disposition of these commodity components: [FW Pre-Eval, FW AMR Report]

- Structural supports for piping, cables and components in the Feedwater System are evaluated for the effects of aging in the Component Supports Commodity Evaluation in section 7.6 of this application

- Electrical control and power cabling for components in the Feedwater System is evaluated for the effects of aging in the Electrical Cables Commodity Evaluation in section 6.2 of this application
- Process and instrument tubing, and tubing supports, for components in the Feedwater System are evaluated for the effects of aging in the Instrument Line Commodity Evaluation in section 6.3 of this application

In accordance with section 5.1 of the CCNPP IPA Methodology, the system intended functions were characterized as either active or passive. The only passive intended function associated with the Feedwater System which is not completely addressed by one of the commodity evaluations referred to above is: [FW Pre-Eval]

- Provide a pressure retaining boundary for the system

The following are the Feedwater System components within the scope of license renewal that perform the passive intended function without moving parts or a change in configuration or properties and, therefore, meet the criteria of §54.21(a)(1)(i) as subject to an aging management review: [FW Pre-Eval, IPA Methodology]

- System piping and in-line components provide the pressure retaining boundary of the system.

Of those, the following components are replaced based on a qualified life of less than 40 years and are therefore not subject to an aging management review in accordance with §54.21(a)(1)(ii): [FW Pre-Eval]

- steam generator level transmitters (Unit 2 only)
- steam generator pressure transmitters (Unit 2 only)

Additionally, all instrument transmitters and instrument valves in the Feedwater System are evaluated in the Instrument Line Commodity Evaluation in section 6.3 of this application. Also, all components of the Feedwater System required to be environmentally qualified in accordance with §50.49 are either replaced based on a qualified life of less than 40 years, or included in the scope of the Instrument Line Commodity Evaluation.

A list of the component types for Feedwater System components evaluated in this section is shown in Table 5.8-1.

TABLE 5.8-1

FEEDWATER SYSTEM COMPONENT TYPES REQUIRING AMR

Piping
Check Valves
Hand Valves*
Motor-Operated Valves
Temperature Elements

* includes only those hand valves not included in the scope of the Instrument Line Commodity Evaluation

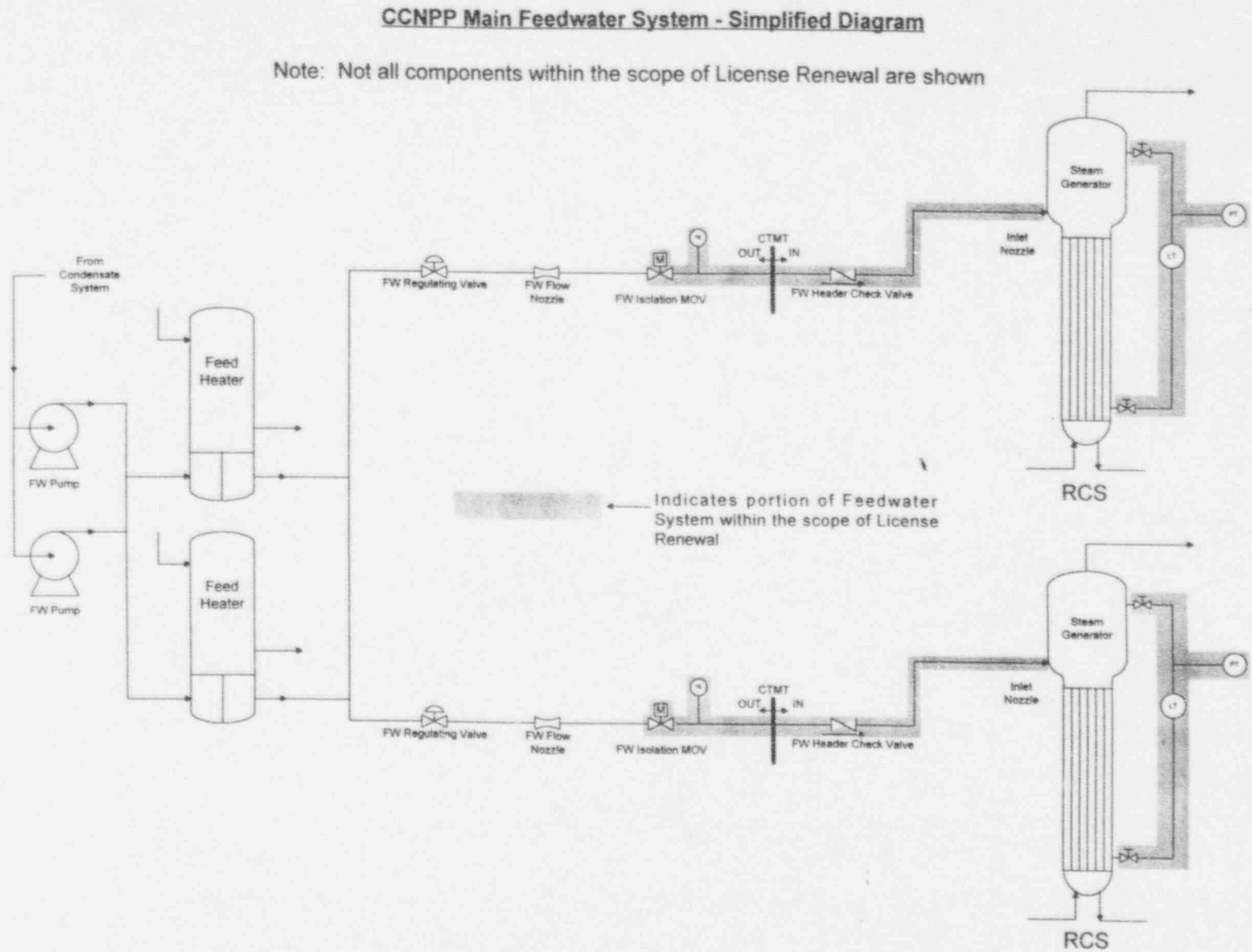

CCNPP Main Feedwater System - Simplified Diagram
Note: Not all components within the scope of License Renewal are shown
From Condensate System
Feed Heater
FW Pump
Feed Heater
FW Pump
FW Regulating Valve
FW Flow Nozzle
FW Isolation MOV
CTMT
OUT
IN
FW Header Check Valve
Inlet Nozzle
Steam Generator
RCS
Indicates portion of Feedwater System within the scope of License Renewal
FW Regulating Valve
FW Flow Nozzle
FW Isolation MOV
CTMT
OUT
IN
FW Header Check Valve
Inlet Nozzle
Steam Generator
RCS

Figure 5.8-1

APPENDIX A

TECHNICAL INFORMATION

7.1 Structures

7.1.1 Scoping

Structures Description

The CCNPP plant site is described in Chapter 1 of the UFSAR. The plant arrangement consists of numerous structures which are shown on UFSAR Figures 1-2 through 1-30 with further discussion of the design features in Chapter 5. Structures provide many purposes at CCNPP including foundation, support, shielding, and containment for plant equipment. [UFSAR Chapter 1 and 5].

In accordance with the CCNPP IPA methodology as described in Section 5.4, the following structures are identified to be within the scope of license renewal: [SLS]

- Intake Structure
- Turbine Building Structure (AFW Pump Room)
- Auxiliary Building Structure
- Containment Structure
- No. 21 Fuel Oil Storage Tank (FOST) Enclosure
- No. 12 Condensate Storage Tank (CST) Enclosure

The general description and layout of the above scope structures at CCNPP is as follows: [UFSAR Chapter 1,5 and 8]

- The **Intake Structure** is located between the Chesapeake Bay shoreline and the turbine building structure. The intake structure, which transfers cooling water from the Chesapeake Bay, is primarily a reinforced concrete seismic category I structure, founded on a slab varying in elevation from -26'0" to -14'3". The intake structure houses 12 circulating water pumps, supplying cooling water to the condensers, and 6 saltwater pumps, supplying cooling water to the salt water cooling system. To protect the pumps and condensers from foreign bodies present in the Chesapeake Bay water, trash racks and traveling water screens are provided. Vertical guides are provided down the sides of each intake channel to receive stop-logs to permit drainage for inspection and maintenance. Running the full length of the structure is a gantry crane having a lifting capacity of 35 tons. Since the saltwater cooling pumps, which are essential for safe shutdown of the CCNPP, are housed in the intake structure, the intake structure is designed for seismic, tornado, and hurricane conditions. The specifics of these loading conditions are provided in UFSAR Table 5-7.

- West of the intake structure is a common **Turbine Building Structure** for both Units 1 and 2 which is oriented parallel and adjacent to the shoreline of the Chesapeake Bay. The turbine building houses the Unit 1 and Unit 2 turbine generators, condensers, feedwater heaters, condensate and feed pumps, turbine auxiliaries, and certain of the switchgear assemblies. The turbine building structure is an integrated steel structure, with metal siding, supported on reinforced concrete foundations. Included in the turbine building are the turbine generator bays, heater bays, and the turbine-generator concrete pedestals which project through the building to the operating deck at elevation 45 feet. The turbine generator Units 1 and 2 are separated by an expansion joint in the super-structure. The circulating water intake and discharge conduits are incorporated into the spread footings. The turbine building is a seismic category II structure with the

exception of the auxiliary feedwater pump enclosure, which is designed as a seismic category I structure and a turbine missile barrier.

- Adjoining the turbine building on its west side is the **Auxiliary Building Structure**. The auxiliary building structure is primarily a reinforced concrete seismic category I structure with a mat foundation. The foundation supports a structural steel and reinforced concrete frame which consists mainly of reinforced concrete walls and floors. On the top structure and over the fuel handling area is a secondary steel frame structure with missile-resistant concrete walls and roof which houses the spent fuel crane. Facilities related to the NSSS which are located in the auxiliary building structure including the following:

  - New and spent fuel handling, storage and shipment
  - Waste processing system
  - Safety injection system
  - Various electrical distribution systems
  - Component cooling
  - Emergency diesel generator rooms
  - Control room
  - Chemical addition system
  - Spent fuel pool cooling system
  - Chemical and volume control system
  - Containment spray

  Since safety-related equipment is housed in the auxiliary building structure, the auxiliary building structure is designed for seismic, tornado, and turbine missile conditions. The specifics of these loading conditions are provided in UFSAR Table 5-6.

  In addition to all other loads including Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE), the steel-framed structure over the spent fuel pool is designed to resist tornadoes and missiles without partial or complete collapse, except for the west wall. A study indicates that the possibility of tornado missiles impacting the spent fuel pool from the west side is remote.

- Twin **Containment Structures** are located north west and south west of the auxiliary building structure with a connective boundary to the auxiliary building structure formed by the shape of the containments. Each Containment Structure is a seismic category I structure, housing the reactor and other NSSS components consisting of a reactor, SGs, RCPs, a pressurizer, and some of the reactor auxiliaries which do not normally require access during power operation. The containment consists of a reinforced concrete cylinder and a shallow domed roof which rests on a reinforced concrete foundation slab. The concrete cylinder and dome have a post tensioned contraction design. Attached to the inside of the containment structure is a coated carbon steel liner. There are three personnel and equipment access openings in the containment: a two-door personnel lock, a large diameter single door equipment hatch, and a two-door personnel escape lock. The primary containment has numerous penetrations for piping and electrical connections. These penetrations are leak tight, inerted assemblies, welded to the containment liner. A fuel transfer tube penetration in the containment is provided permit fuel movement between the refueling pool in the containment and the spent fuel pool in the auxiliary building. Two sumps are provided in the containment floor: a normal and emergency sump.

  The Containment Structure, in conjunction with Engineered Safety Features (ESFs), is designed to withstand an internal pressure of 50 psig, a coincident concrete surface temperature of 276°F and a leak rate of 0.20% by weight per day at design temperature and pressure. Since safety-related equipment is housed

in the containment structure, the containment structure is designed for seismic, tornado, and turbine missile conditions. The specifics of these loading conditions are provided in UFSAR Section 5.A.3.

- The **Fuel Oil Storage Tank No. 21 Enclosure** is seismic category I reinforced concrete located to the west of the containments. It houses the Fuel Oil Storage Tank (FOST) No. 21 which is a shared fuel supply for the emergency diesel generators. The enclosure protects No. 21 FOST from tornado-generated missiles and tornado winds by a seismic category I concrete structure. This structure will also withstand the impact of a transmission tower falling on it without damage to the fuel oil storage tank contained within the structure. Bursting pressures are relieved by baffled, missile-proof vents.

- The **Condensate Storage Tank No. 12 Enclosure** is a seismic category I reinforced concrete structure located north of the turbine building in the tank farm area. It houses Condensate Storage Tank No. 12 which is shared between the units. Tornado protection for the tank consists of a seismic class I concrete structure of sufficient thickness to stop tornado-generated missiles and to resist tornado wind pressures. Bursting pressures are relieved by baffled, missile-proof vents.

Structures have been grouped together since they are designed and constructed in a similar manner, comprised of the same materials, subject to the same aging mechanisms, and are managed by similar plant programs. Each structure within the scope of License Renewal and subject to an aging management review has a separate aging management review report which is listed in the references at the end of this section.

In accordance with Section 4.2.2 of the CCNPP IPA Methodology, Structures are determined to perform one or more of the functions listed in Table 7.1-1 in support of the §54.4 (a) scope criteria: [IPA Meth, AMRs]

- Functions 1-4 are associated with seismic category I structures. Seismic category I design requirements are the structure level equivalent of SR components specified in §54.4 (a) (1).
- Functions 5 and 6 apply to non-seismic category I structural components which could, if they fail, prevent a SR function from occurring. This is the structural equivalent for §54.4 (a) (2).
- Function 7 is the equivalent for the fire protection (§50.48) portion of §54.4 (a) (3) which is applicable to structures.
- Function 8 is a system level function for containment system type components and is the environmental qualification (§50.49) portion of §54.4 (a) (3).

APPENDIX A

TECHNICAL INFORMATION

TABLE 7.1-1

INTENDED FUNCTIONS OF STRUCTURES

Function	Containment	Auxiliary Building	Intake Structure	Turbine Building	No. 21 FOST Enclosure	No. 12 CST Enclosure
1. Provide structural and/or functional support to safety-related equipment	✓	✓	✓	✓	✓	✓
2. Provide shelter/protection to safety-related equipment. (This function includes radiation protection for EQ equipment and high energy line break-related protection equipment.)	✓	✓	✓	✓	✓	✓
3. Serve as a pressure boundary or a fission product retention barrier to protect public health and safety in the event of any postulated DBEs	✓	✓				
4. Serve as a missile barrier (internal or external)	✓	✓	✓	✓	✓	✓
5. Provide structural and/or functional support to NSR equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions (Example: seismic Category II over I design considerations)	✓	✓	✓	✓	✓	
6. Provide flood protection barrier (internal flooding event)	✓	✓	✓	✓		
7. Provide a rated fire barrier to confine or retard a fire from spreading to or from adjacent areas of the plant	✓	✓	✓	✓		
8. Maintain the functionality of electrical components addressed by the EQ program.	✓					

APPENDIX A

TECHNICAL INFORMATION

Scoped SCs and Their Intended Functions

During the scoping process, structural components were identified for each structure within the scope of License Renewal. These structural components were grouped into 4 structural categories and 1 system category based on their design and materials.

1. Concrete Components,
2. Structural Steel Components,
3. Architectural Components,
4. Unique Components, and
5. System Type Components.

Within those five structural component groups, 59 different structural component types were identified as contributing to the intended functions of the structure. Table 7.1-2 lists these component types and the structures to which they are applicable. Functions from Table 7.1-1 indicate which structural component contributes to the intended functions.

Several structural component types are common to many plant systems and perform the same passive intended functions, (e.g., piping and component supports). As described in Section 2.0, these are addressed separately as commodity groups and are not included in this section. They include the following:

- Component supports that are connected to the structures are evaluated for the effects of aging in the Component Supports Commodity Evaluation in section 7.6 of this application.
- Cranes and fuel handling equipment which is connected to the structures is evaluated for the effects of aging in the Cranes and Fuel Handling Commodity Evaluation in section xx.xx of this application.
- Electrical control and power cabling for components in the Containment System is evaluated for the effects of aging in the Electrical Cables Commodity Evaluation in section 6.2 of this application.

While the first seven functions are of a structural nature, the eighth function is a system-type function provided by the EQ electrical penetrations. Aging management for these penetrations is provided by the CCNPP 50.49 Program aging management review which is provided in a separate LRA section.

APPENDIX A

TECHNICAL INFORMATION

TABLE 7.1-2

STRUCTURAL COMPONENT TYPES REQUIRING AMR

	Containment	Auxiliary Building	Intake Structure	Turbine Building	No. 21 FOST Enclosure	No. 12 CST Enclosure
Concrete (Including Reinforcing Steel)						
Foundations (Footings, beams, and mats)		1, 5	2		1, 2	1, 2
Columns	1, 5	1, 5	2, 4, 7			
Walls		1, 2, 4, 5, 6, 7	1, 2, 4, 7	1, 2, 4, 6, 7	2, 4	2, 4
Beams	1, 5	1, 5	2, 4			
Ground Floor Slabs/Equipment Pads		1, 5	1, 2	1, 2, 4, 6, 7		
Elevated Floor Slabs	1, 5	1, 2 , 5 ,7	1, 2	1, 2, 6, 7		
Roof Slabs		2, 4	2		2, 4	2, 4
Cast-In-Place Anchors/Embedments•	1, 5	1	1, 2, 6, 7	1, 2, 6, 7	1, 2, 4, 5	1, 2, 4
Ductbanks				1, 2		
Grout	1, 5	1, 5	1, 2	1, 2, 6, 7	1, 2, 4, 5	2
Concrete Blocks (Shielding)		2				
Removable Missile Shield	4					
Fluid Retaining Walls and Slabs		1	1, 2, 6	1, 2, 6, 7		
Masonry Block Walls		1, 2, 5, 6, 7				
Post-Installed Anchors•	1	1, 5	2, 5	4, 5	5	
Structural Steel						
Columns•	1,5	1, 5				
Beams•	1, 5	1, 5	1, 2	1, 2, 7	2, 4	2, 4
Baseplates•	1,5	1, 5	1, 5	1, 2, 4, 5, 7	2, 4	2, 4
Floor Framing•	1, 5	1, 5	1, 5	1, 5		
Roof Framing•		1, 4, 5	2		2, 4	2, 4
Roof Trusses•		1, 4, 5				
Bracing•	1, 5	1, 5	2, 5	4	5	
Platform Hangers•	1, 5	1, 5	5	5	5	

TABLE 7.1-2 (Cont.)

STRUCTURAL COMPONENT TYPES REQUIRING AMR

	Containment	Auxiliary Building	Intake Structure	Turbine Building	No. 21 FOST Enclosure	No. 12 CST Enclosure
Structural Steel						
Decking•	1, 5	1, 5	2	1, 2, 7	2, 4	2, 4
Jet Impingement• Barriers		2		4		
Liners	3	3				
Floor Grating•	1, 5		5	5	5	
Checkered Plates•	1, 5		2			
Stairs and Ladders•			5	5	5	
Architectural Components						
Building Siding Clips•				2		
Fire Doors, Jambs, and Hardware•		7	2, 7	2, 6, 7		
Access Doors, Jambs, and Hardware•		2	2	2, 6, 7		
Caulking and Sealants		2, 6, 7	2, 6, 7	2, 6, 7	1, 2	1, 2
Coatings (including galvanizing)	1, 2, 3, 4, 5, 7					
Unique Components						
Concrete Basemat	1, 2, 3, 4, 5, 6, 7					
Concrete Dome	1, 2, 3, 4, 5, 7					
Concrete Containment Walls	1, 2, 3, 4, 5, 6, 7					
Primary/Secondary Shield Wall	1, 2, 4					
Refueling Pool Concrete	1, 6					
Refueling Pool Liner	3					
Post Tensioning System	1, 2, 3, 4					
Crane Girder•	5					

APPENDIX A

TECHNICAL INFORMATION

TABLE 7.1-2 (Cont.)

STRUCTURAL COMPONENT TYPES REQUIRING AMR

	Containment	Auxiliary Building	Intake Structure	Turbine Building	No. 21 FOST Enclosure	No. 12 CST Enclosure
Unique Components						
Lubrite Plates•	1, 5					
Maranite XL Board	7					
New Fuel Rack Assembly•		1				
Spent Fuel Storage Racks		1				
Monorail•		5				
Cask Handling Crane Rail/Supports•		1, 5				
Lead Brick Shielding		2				
Pipe Whip Restraints•		2				
Roll-Up Doors•		2				
Expansion Joints		2, 7				
Watertight Doors•		6, 7	6	2, 6, 7		
Sluice Gates•			1			
Anchor Brackets•					1	
System Type Components						
Electrical Penetrations (Non-EQ)	3					
Mechanical Penetrations	3					
Fuel Transfer Tube/ Bellows	3					
Personnel Airlocks	3, 7					
Equipment Hatch	3, 7					

* Indicates that component type is included under the heading "Steel Components" in the discussion addressing the results of the AMR and in Table 7.1-3.

7.6 COMPONENT SUPPORTS

7.6.1 Scoping

Commodity Approach for Component Supports

"Component support" is defined as the connection between a system, or component within a system, and a plant structural member (e.g., the concrete floor or wall, structural beam or column, or ground outside the plant buildings). [AMR] Supports for *structural* components are not "component supports" in this sense because any support for a structural component is itself a structural component. [CCNPP IPA Methodology]

Component supports are associated with equipment in almost every plant system. They perform the same basic function, regardless of the system with which they are associated. For this reason, it was determined that a commodity evaluation of component supports would be more efficient to address these supports than evaluating them as part of each system Aging Management Review. [CCNPP IPA Methodology]

Commodity Description

As discussed in the CCNPP IPA Methodology section on commodity evaluations (section 7.2), component supports are scoped using a process similar to the scoping process for structures, as follows. A generic list of component support types was developed by reviewing industry and plant-specific information, including Seismic Qualification Utility Group guidance, American Society of Mechanical Engineers Section XI component support inspection documentation and the CCNPP System Level Scoping Results. All component support types which provide support to equipment within the scope of license renewal are identified and listed as within the scope of license renewal. Systems having component supports addressed in this section are identified in Table 7.6-1. [CCNPP IPA Methodology]

Supports for both the distributive portions of systems, such as piping and cable raceways, and system equipment items are included in the scope of this section. The total population of component supports are grouped into four categories based on the items they support (piping, cable raceways, HVAC ducting, and equipment) and then into 20 component support types. Component support types are based on similarities of design, loading condition, and environment. All categories and types are shown in Table 7.6-2. [AMR]

Supports for the steam generators and reactor vessel are not included in this commodity evaluation but are addressed in Sections 4.1 and 4.2, respectively. Supports for the spent fuel pool cooling demineralizer and filter vessel are also addressed separately, in Section 5.7.

Basic design basis information for certain supports is discussed in UFSAR chapters 1 (Principal Architectural and Engineering Criteria for Design), 5 (Containment Structure, Design Criteria), 5A (Structural Design Basis), 6 (Engineered Safety Features Design Basis), and 10 (Steam and Power Conversion Systems). [AMR]

Scoped SCs and Their Intended Functions

All component supports within the scope of license renewal were considered to be subject to aging management review except snubbers, which were excluded as active equipment by §54.21(a)(1)(i). [CCNPP IPA Methodology]

Because the component supports subject to aging management review support components that provide functions meeting §54.4(a) (1), (2), and (3), the supports were determined to have the following passive intended functions, which directly correlate:

a. Provide structural support for safety-related systems and components.

b. Provide structural support for non-safety-related equipment where failure of this structural component could directly prevent satisfactory accomplishment of safety-related functions.

c. Provide structural support for non-safety-related systems and components which are required for fire protection, environmental qualification, pressurized thermal shock, anticipated transients without scram, and station blackout, and credited in the analysis for these events included in the current licensing basis (CLB). [AMR]

The design loading conditions for component supports include factors such as dead loads, thermal loads, seismic loads, etc. Supporting information for specific loading conditions of specific supports is maintained on site. [UFSAR][ES-040]

TABLE 7.6-1

SYSTEMS WITHIN THE SCOPE OF LICENSE RENEWAL
CONTAINING SUPPORTS WITHIN THE COMMODITY EVALUATION
(CCNPP system numbers are shown in par 'heses)

(002) Electrical 125 Volt DC Distribution (004) Electrical 4 kV Transformers and Busses (005) Electrical 480 Volt Transformers and Busses (006) Electrical 480 Volt Motor Control Centers (008) Well and Pretreated Water (011) Service Water Cooling (012) Saltwater Cooling (013) Fire Protection (015) Component Cooling Water (017) Instrument AC (018) Vital Instrument AC (019) Compressed Air (020) Data Acquisition Computer (023) Diesel Fuel Oil (024) Emergency Diesel Generators (026) Annunciation (029) Plant Heating (030) Control Room Heating, Ventilation and Air Conditioning (HVAC) (032) Auxiliary Building and Radwaste Heating and Ventilation System (036) Auxiliary Feedwater	(037) Demineralized Water and Condensate Storage (038) Sampling System (Nuclear Steam Supply System [NSSS]) (041) Chemical and Volume Control (042) Circulating Water (044) Condensate (045) Feedwater (047) Technical Support Center Computer (048) Emergency Safety Features Actuation (055) Control Rod Drive Mechanisms and Electrical (058) Reactor Protection (060) Primary Containment HVAC (061) Containment Spray (062) Control Boards (064) Reactor Coolant (067) Spent Fuel Pool Cooling (069) Waste Gas (073) Hydrogen Recombiner (077/79) Area and Process Radiation Monitoring (078) Nuclear Instrumentation (083) Main Steam (097) Lighting and Power Receptacles

TABLE 7.6-2

COMPONENT SUPPORT COMMODITY TYPES REQUIRING AN AMR

Component Support Group	Associated Systems (see Table 7.6-1 for system title)
Piping Supports	008 011 012 013 015 019 023 024 029 036 037 038 041 045 052 061 067 083 (Note 1)
Spring Hangers, Constant Load Supports, Sway Struts, Rod Hangers, and Snubber Supports[1] Outside Containment	
Spring Hangers, Constant Load Supports, Sway Struts, Rod Hangers, and Snubber Supports[1] Inside Containment	
Piping Frames Outside Containment	
Piping Frames Inside Containment	
Cable Raceway Supports	Cables are not assigned to specific systems.
Channel, Clamp, and Other Supporting Styles Outside Containment	
Channel, Clamp, and Other Supporting Styles Inside Containment	
HVAC Ducting Supports	
Rod Hanger Trapeze Supports Outside Containment	030 032
Rod Hanger Trapeze Supports Inside Containment	060
Equipment Supports	
Anchorage Including Elastomer Vibration Isolators	030 032
Electrical Cabinet Anchorage Outside Containment	002 004 005 006 017 018 020 024 026 038 048 055 057 058 062 077/79 078 097 (Note 2)
Electrical Cabinet Anchorage Inside Containment	077/079
Electrical Equipment (load bearing insulation material)	002 004 005
Equipment Frames (Instruments/Batteries on Racks) Outside Containment	002 008 011 012 015 019 023 024 029 030 032 036 038 042 044 045 052 061 067 069 083
Equipment Frames (Instruments on Racks) Inside Containment	013 038 041 045 052 064 073 083
Frames and Saddles (Tanks and Heat Exchangers) Outside Containment	011 012 013 015 019 023 024 029 036 038 041 061 064 067 069
Frames and Saddles (Tanks and Heat Exchangers) Inside Containment	041 052 064 073
Metal Spring Isolators and Fixed Bases Outside Containment	008 011 012 013 015 019 023 024 029 032 036 041 044 052 061 067
Metal Spring Isolators and Fixed Bases Inside Containment	060 064
Loss-of-Coolant Accident (LOCA) Restraints	064
Ring Foundations for Flat-Bottom Vertical Tanks	008 023 037 052

Note 1: Correlation of piping support types to individual systems is not relevant to the AMR results. See more discussion under "Piping Supports."

Note 2: Local control panels and distribution panels in a variety of fluid systems were evaluated in the Electrical Panels Commodity Evaluation and their supports are included in this support group.

---

1 Snubber supports include the hardware from the wall and piping/equipment to the snubber pin connections. The snubber itself is not subject to AMR.

License Renewal
Scoping/Pre-Evaluation Discussions

October 10, 1996

Discussion Topics

- System Level Scoping
  - Emphasis on Feedwater and structures
- Component Level Scoping for Feedwater System
- Component Level Scoping for Auxiliary Building
- Pre-Evaluation for the Feedwater System
- Scoping/Pre-Evaluation and Commodity Evaluations

BGE

Life Cycle Management Unit

System Level Scoping Process

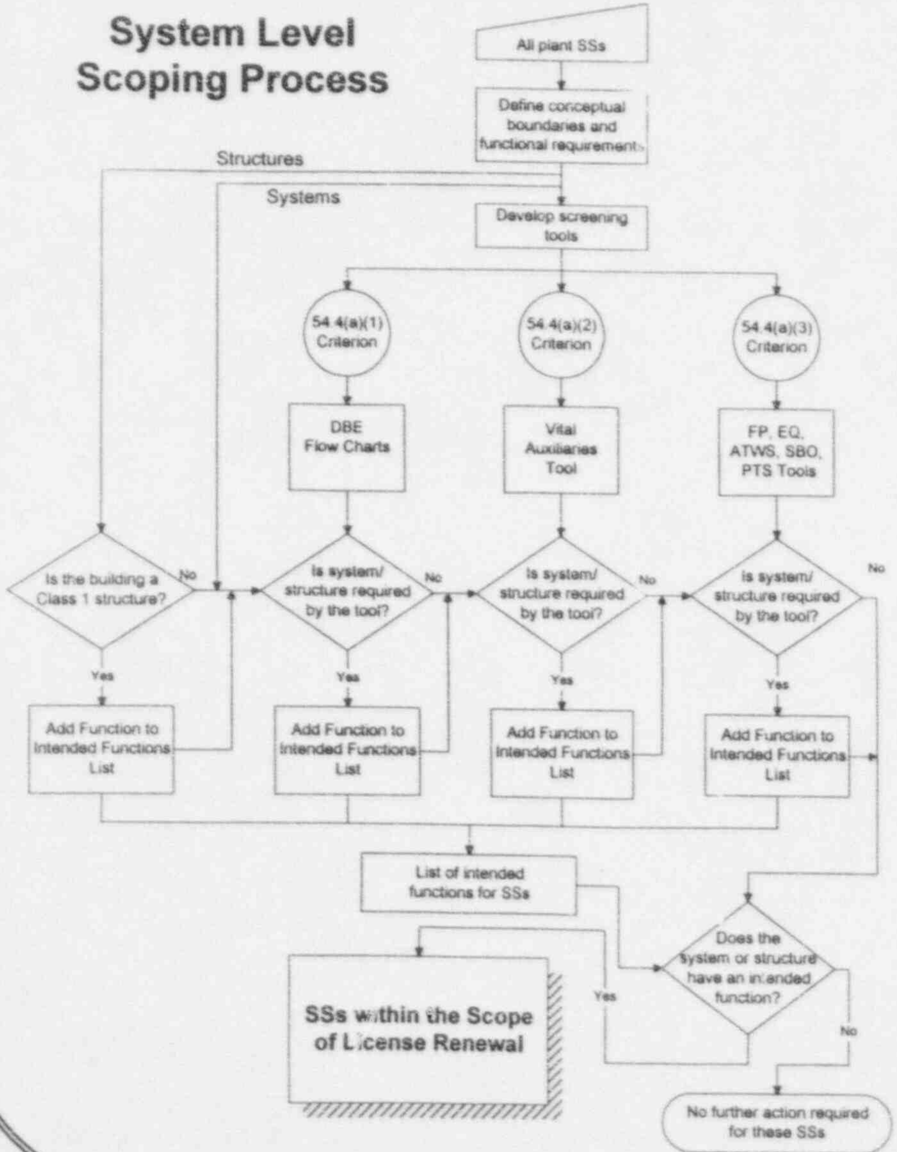


Figure 3-1

System Level Scoping

- **Methodology Section 3**
- **Steps**
  - Identify system/structure conceptual boundaries
  - Prepare screening tools
  - Screen systems and structures
- **Results**
  - System/Structure Information
  - Screening Tools
  - System Level Scoping Results

System/Structure Information

BGE LCM Program
TABLE 1
SYSTEM/STRUCTURE INFORMATION

Revision 4

System/structure	Unit	ID	Summary Description	Description Reference	Functional Requirement(s)	Function Reference
Condensate (continued)	1&2	44	The condensate system interfaces with the following systems and components: · Main feedwater system · Condensate demineralizer system · Condensate pump seals · Condensate precoat filter system · Main turbine exhaust hood spray · Condensate discharge to circulating water system · Auxiliary boiler deaerator · Component cooling and service water makeup · Condensate exhaust trunk expansion joint · Coolant waste evaporator condensate return · Feedwater chemical addition system · Steam generator blowdown heat exchanger · Heater drains		5. To provide a backup source of supply for makeup to the component cooling and service water systems. 6. To provide seal water to the seals of the heater drain pumps and the steam generator feed pumps. 7. To provide cooling water to the drain coolers and steam seal exhaust condenser. 8. To provide a means of condenser hotwell level control.	
Feedwater	1&2	45	The condensate booster pumps deliver the condensate to the two turbine-driven steam generator feed pumps through two parallel sets of three feedwater heaters. The steam generator feed pumps pump the feedwater through two parallel high-pressure heaters to the steam generators. The main feedwater system consists of turbine-driven centrifugal steam generator feed pumps (SGFP), minimum (mini) flow control valves, a pump seal water system, feedwater regulating valves, feedwater regulating valve bypass valves, HP and LP feedwater heaters, and associated piping and instrumentation. The main feedwater system interfaces with the following systems/components: · Condensate system · Main steam system · Chemical addition system · Emergency safety features actuation system · Seal water booster pump · Extraction steam system. · Steam Generators	SD No. 32 Pgs. 2, 5 UFSAR Section 10.2.2	1. To transfer feedwater from the steam generator feed pump suction to the steam generators. 2. To regulate the flow of feedwater to the steam generators to maintain a constant water level in the steam generators. 3. To provide a means of raising the temperature of the condensate received by the feed pumps. 4. To provide a means for injecting chemicals into the steam generators from the chemical addition system.	SD No. 32 Pgs. 2, 5 UFSAR Section 10.2.2
Extraction Steam	1&2	46	The extraction steam is used to increase the temperature of the feedwater prior to its entering the steam generators. Wet steam is directed from the low pressure and high pressure feedwater heaters in the condensate and feedwater systems. The major components are the feedwater heaters, turbine bleeder trip valves, extraction line drain valves and associated piping. The extraction steam system interfaces with the following systems/components: · Feedwater heaters, drains, and vents system · Reheat steam system · Scavenging steam · Reactor coolant waste evaporator system · Miscellaneous waste processing system · Main steam system.	SD No. 25 Pgs. 1 thru 3 UFSAR Section 10.2.2	1. To increase the temperature of the feedwater prior to its entering the steam generators, which results in an increase in overall plant efficiency. 2. To minimize thermal shock in the steam generators. 3. To assist in removing moisture from the high pressure turbine 3rd stage by supplying steam to the 1st stage of the moisture separator reheater.	SD No. 25 Pg. 1

System/Structure Information

LCM-12 Revision 6

BGE LCM Program
TABLE 1
SYSTEM/STRUCTURE INFORMATION

Revision 4

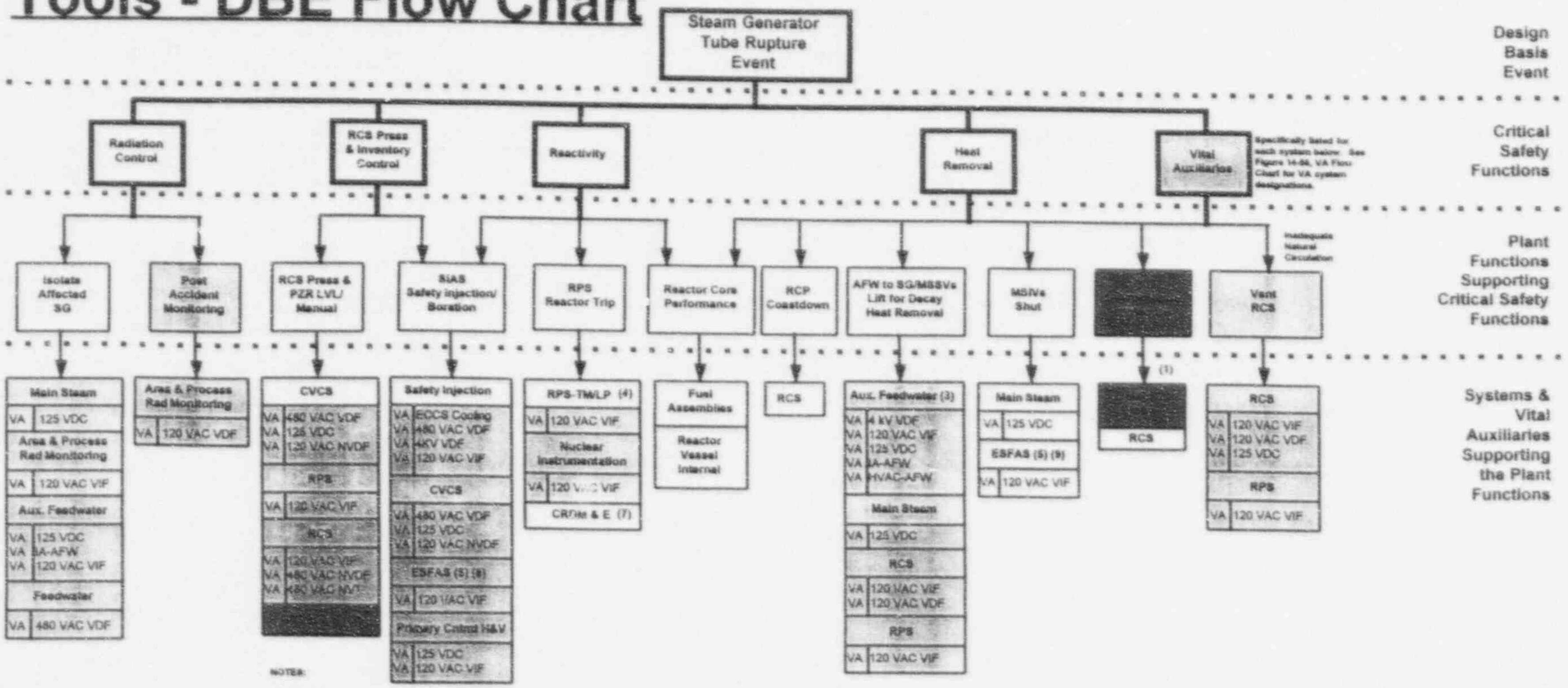
System/structure	Unit	ID	Summary Description	Description Reference	Functional Requirement(s)	Function Reference
Docks and Marine Related Structures (continued)	Both	108	The channel's edge is 4800 feet to the east of the intake structure. At the baffle wall, the intake channel is approximately 560 feet wide. At a point approximately 2800 feet from the intake structure, the channel begins to narrow and has an average width of 400m feet for the remainder of the channel. The baffle wall is located approximately 300 feet east of the intake structure and spans the entire 560 feet width of the intake channel. The entire baffle assembly is about 56 feet tall and extends 5 feet above the water. The bottom of the upper baffle wall is at an elevation of -28 feet and is designed to allow bay water to flow under the wall at a rate of less than one half foot per second. The dock is located on the Chesapeake Bay at the end of Barge Road on the southeast end of the plant. The barge road dock was used frequently during CCNPP construction to receive heavy plant components which were transported via water. Currently, the dock is only used lightly as a convenient location for miscellaneous purposes, such as sand blasting and baffle wall repair. The dock contains a two ton fixed crane, electric power for lighting and miscellaneous use, and a communications system.			
Barriers and Barrier Penetrations	Both	120	Fire walls, ceilings/floors, doors and penetration seals are installed in vital areas of the plant as rated fire barriers. Cable trays are provided with rated fire barriers to ensure redundant cables are adequately separated and not subject to common mode failure during a postulated severe fire.	FP Screening Tool Pg. 12	1. To confine or retard a fire from spreading to adjacent areas of the plant. 2. To provide separation of redundant cables to ensure safe shutdown in the event of a postulated severe fire.	FP Screening Tool Pg. 12
Auxiliary Building	Both	–	The auxiliary building is primarily a reinforced concrete structure and the mat foundation supports a structural steel and reinforced concrete frame which consists mainly of reinforced concrete walls and floors. On the top structure and over the fuel handling area is a secondary steel frame structure with missile-resistant concrete walls and roof which houses the spent fuel crane. Facilities related to the NSSS which are located in the auxiliary building include: -New and spent fuel handling, storage and shipment -Control room -Waste processing system -Chemical addition system -Safety injection system -Spent fuel pool cooling system -Various elecrical distribution systems -Chemical and volume control system -Component cooling -Containment spray The auxiliary building is a Class I structure below 69' elevation. The reinforced concrete design is in accordance with ACI 318-63 and the structural steel is in accordance with AISC.	UFSAR Section 5.6.1 UFSAR Section 5.0 Appendix 5-A	1. To provide housing for plant systems and ensure safe shutdown under any condition. 2. To provide shielding to maintain radiation levels outside the auxiliary building within established limits. 3. To provide safe access to equipment for operation requirements 4. To maintain its integrity and protect safety related plant equipment from damage under various design loads including design basis earthquake and missiles.	UFSAR Section 5.6.1 UFSAR Section 5.0 Appendix 5-A UFSAR Section 11.2.2.5

4A

BGE

Life Cycle Management Unit

Tools - DBE Flow Chart



NOTES:

(1) CRDM & E's CEA Motion Inhibit (CMI) is assumed to be operable. (UFSAR 14.1.3.3)

(2) CRDM & E is required to maintain PB of the RCS.

(3) The Feedwater and RPS systems provide signals to AFAS.

(4) One or more of the following systems may provide signals to RPS:

- RCS
- Nuclear Instrumentation
- Feedwater
- ESFAS

(5) One or more of the following systems may provide signals to ESFAS:

- Area & Process Radiation Monitoring
- Electrical 4kV Transformers and Buses
- Safety Injection
- Feedwater
- RPS
- RCS

(6) Any system interfacing with RPS and/or ESFAS should be reviewed to determine if that system provides the function of loop protection and isolation from electrical faults.

(7) The CEAs are controlled as safety related in DS-011, Attachment 3.

(8) ESFAS may send control signals to the following systems directly or via the LOCI sequencer upon SIAS actuation:

- Emergency Diesel Generator
- RCS
- Aux. Bldg & Radwaste H&V
- Safety Injection
- Containment Spray
- Auxiliary Feedwater
- CVCS
- Primary Cntmt H&V
- Compressed Air
- Sampling (NSSS)
- Service Water
- Plant Heating
- Plant Drains
- Component Cooling
- Area & Process Rad Monitoring
- Salt Water
- Liquid Waste
- Control Room HVAC

(9) ESFAS may send control signals to the following systems upon SGIS actuation:

- Main Steam
- Feedwater (SLB inside containment only)
- Condensate (SLB inside containment only)
- Feedwater Heater Drain & Vents (SLB inside containment only)

LEGEND

- Ref. UFSAR & 61403SH0015
- Ref. 61403SH0015
- Ref. UFSAR Only

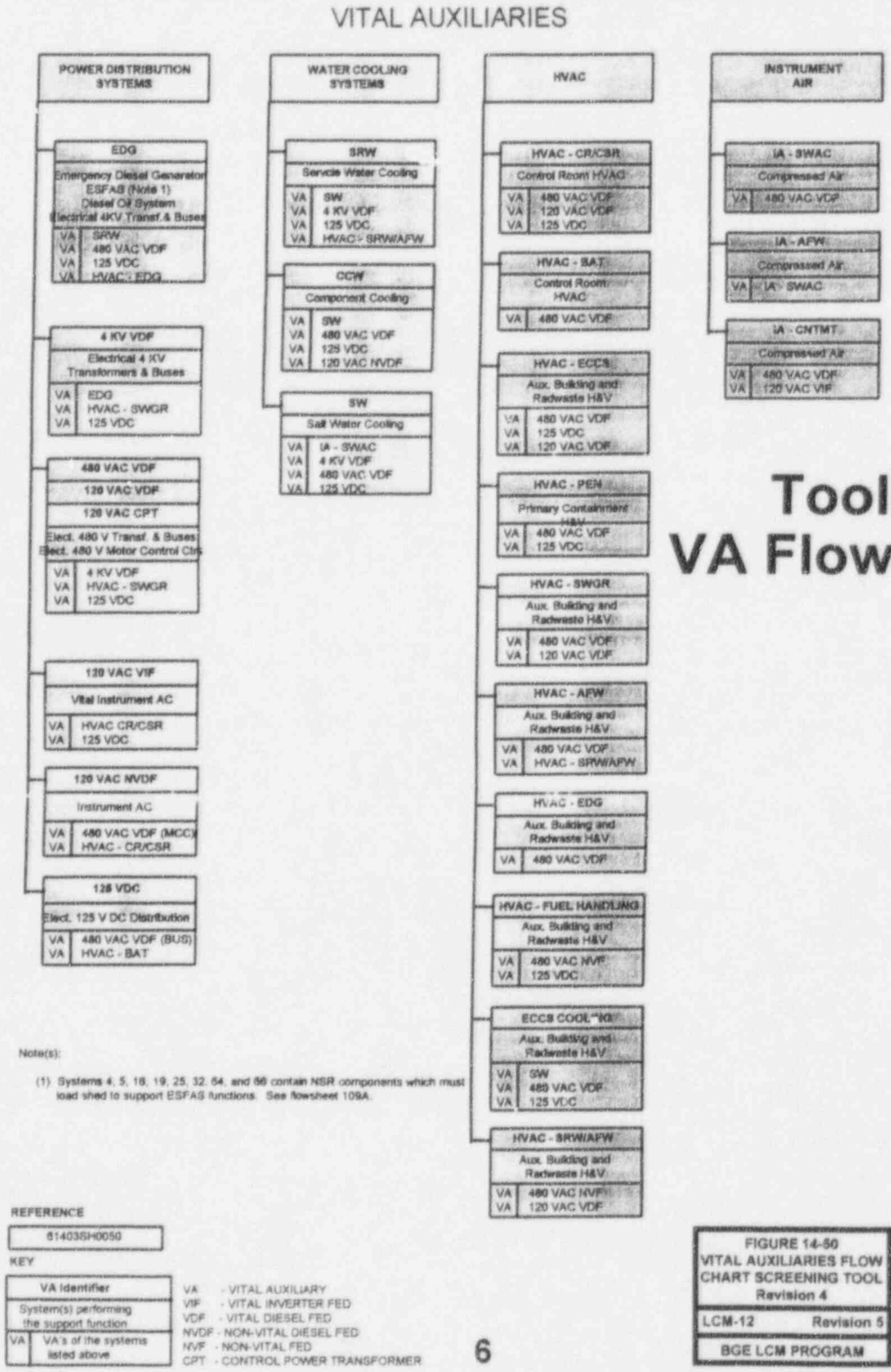
FIGURE 14-15
DBE No. 15 FLOW CHART
SCREENING TOOL
Revision 4

LCM-12 Revision 5

BGE LCM Program

Life Cycle Management Unit

Tools - VA Flow Chart



Tools - FP Screening Tool

LCM-12 Revision 5

Fire Protection (FP) Screening Tool — Revision 4

SYSTEM/ STRUCTURE	S/U Sys ID No.	FIRE PROTECTION (FP) FUNCTION / SAFE SHUTDOWN (SS) FUNCTION	SOURCE DOCUMENT	SECTION/ PAGE
Demin Water and Condensate Storage	37	SS Provides back-up source of AFW water to support RCS Heat Removal. * Includes manual realignment of CST * Includes condenser make-up path isolation	Ref 2	Att 1, pg 21 Att 2, Fig 11 and 15
		SS Provides make-up water to SRW/CC systems via system hose connections to support RCS Pressure & Inventory Control, and Heat Removal (Cold Shutdown).	Ref 2	Att 1, pg 15, 23 Att 2, Fig 12 and 15
Chemical and Volume Control System	41	SS Provides primary make-up to support RCS Pressure & Inventory Control. * Includes realignment to auxiliary spray mode [Notes 3, 5]	Ref 2	Att 1, pg 13, Att 2, Fig 3 and 8
Condensate	44	SS Provides make-up water to SRW/CC systems via system hose connections.	Ref 2	Att 1, pg 15, 21 and 23 Att 2, Fig 12, 15 and 17
Feedwater System	45	SS Monitor Steam Generator Level to support safe shutdown in the event of a postulated severe fire.	Ref 2	Att 1, pg 18, 19 Att 2, Fig 20 and 21
Safety Injection	52	SS Provides RCS Pressure & Inventory Control to ensure safe shutdown in event of a postulated severe fire. * Includes SI tank isolation [Notes 3, 5]	Ref 2	Att 1, pg 14 Att 2, Fig 3
		SS Provides RCS Heat Removal by realigning and operating in the shutdown cooling mode to ensure safe shutdown in the event of a postulated severe fire. [Notes 2, 3, 5]	Ref 2	Att 1, pg 22 Att 2, Fig 5

Page 8 of 12

BGE LCM PROGRAM

BGE

Life Cycle Management Unit

Tools - ATWS Screening Tool

LCM-12 Revision 5

ATWS Screening Tool		Revision 4
Reference 1 -		Calvert Cliffs Nuclear Power Plant, Units 1 & 2, Updated Final Safety Analysis Report (UFSAR), Section 7.10 & 7.11.
SYSTEM/ STRUCTURE	**SYSTEM ID NO.**	**ATWS FUNCTION(S)**
Auxiliary Feedwater	36	* Provide AFAS START signal (diverse from RPS) on low steam generator water level conditions indicative of an ATWS (AFAS); components include isolators, bistables, initiation relays. and logic modules.
Feedwater	45	* Provide AFAS START signal (diverse from RPS) on low steam generator water level conditions indicative of an ATWS (AFAS) ; components include level transmitters.
Emergency Safety Feature Actuation (ESFAS)	48	* Process sensed signals/provide reactor trip signal (diverse from RPS) on high pressurizer pressure conditions indicative of an ATWS (DSS); components include isolators, bistables, logic modules, and initiation relays. * Process sensed signals/provide turbine trip signal (diverse from RPS) on CEDM undervoltage conditions indicative of an ATWS (DTT); components include isolators, bistables, logic modules, and initiation relays.
Control Rod Drive Mechanism and Electrical	55	* Interrupt power to the CEDMs/initiate reactor trip on DSS signal; components include CEDM motor generator output contactors.
Reactor Protective	58	* Process sensed voltage signals for ESFAS (DTT) trips; components include CEDM power bus undervoltage sensors, intermediate sensor relays. * Provide signal to DSS circuits on high pressurizer pressure conditions; components include pressure transmitters.
Main Steam	83	* Initiate turbine trip on DTT signal; components include hydraulically controlled reheater stop valves (Unit 2).
Main Turbine	93	* Interrupt power to the Main Turbine Trip solenoid valves/initiate turbine trip on DTT signal; components include trip solenoid valves (both units), intermediate initiation relays and hydraulically controlled intermediate stop valves (Unit 1), hydraulically controlled auto stop valve (Unit 2), and hydraulically controlled turbine stop valves (both units).
	GENERAL -	Any systems providing signal inputs to the systems listed above should be reviewed to determine if that system provides the function of loop protection and isolation from electrical faults.

Page 1 of 1

BG&E LCM PROGRAM

System Level Scoping - Structures

Excerpts for ES-011 "SSC Evaluation" (Q List Basis Document)

c) Structures

Seals and expansion joints for safety-related structures are SR-CAT I.

Turbine Building siding clips are SR-CATI (reference UFSAR 10.A.1.20.1).

The following structures have been designed as SR-CATI and all non-safety-related items in them (except as not in Attachment 3, Section 2.b.9)b)) shall be mounted structurally as safety-related. Otherwise, these structures are AQ-II/I:

- Containment Structures.
- The emergency sump including grating enclosure is SR-CATI (CLASS-649).
- The reactor cavity pool seal is SR-PB (CLASS - 2Q9300104).
- The reactor cavity neutron shield is AQ-II/I (CLASS - 2Q9300104, Rev. 1).
- Auxiliary Building (excluding those areas listed in UFSAR Section 3.2.9.2 and the west wall above elevation 69'0").
- Intake Structure (circulating water and saltwater enclosure portion).
- Diesel Generator Rooms.
- Refueling Water Tank Pumps Rooms.
- Condensate Storage Tank 12 Enclosure Structure.
- Fuel Oil Storage Tank 21 Enclosure Structure.
- Auxiliary Feedwater Pump Rooms.
- Diesel Generator DG0C Electrical Ductbank (excluding those areas listed in UFSAR Sections 5.2.10.5 and 5.2.10.6) (CLASS-2Q9300111, CLASS-2Q9400020).

•

Life Cycle Management Unit

System Level Scoping Results

LCM-12 Revision 5

BGE LCM PROGRAM
TABLE 2
SYSTEM LEVEL SCOPING RESULTS

Revision 4

System/Structure	Unit	ID	CRITERIA 1 & 2: Req'd for DBE	CRITERIA 1 & 2: DBE Plant Function(s)	CRITERIA 1 & 2: Q	CRITERIA 1 & 2: Class I or SR-1M	CRITERIA 1 & 2: Class I or SR-1M Reference	CRITERION 3: PAM	CRITERION 3: FP	CRITERION 3: ATWS	CRITERION 3: SBO	CRITERION 3: PTS	CRITERION 3: EQ	In Scope Yes/No
Chemical and Volume Control (CVCS) (continued)			No. 15 No. 16 No. 17 No. 26											
Circulating Water	1&2	42	No	None	Yes	N/A	N/A	No	No	No	No	No	No	Yes
Condenser Air Removal	1&2	43	No	None	No	N/A	N/A	No	No	No	No	No	No	No
Condensate	1&2	44	No	None	No	N/A	N/A	No	Yes	No	No	No	No	Yes
Feedwater	1&2	45	No. 2 No. 3 No. 4 No. 5 No. 6 No. 7 No. 9 No. 10 No. 12 No. 13 No. 14 No. 15 No. 16 No. 17 No. 18 No. 26	Cntmt Overpressure Protection (#14) Prevent Reverse Flow from SG (#26) Cntmt Press Control & Cooling (#13,14,17) Provide Signals to ESFAS (#14,15) Provide Signals to RPS (#4,6,7,12,14,26) Provide Signals to AFAS (NOT #7 & #26) Isolate Affected S/G (#14,15)	No	N/A	N/A	Yes	Yes	Yes	Yes	No	Yes	Yes
Extraction Steam	1&2	46	No. 13 No. 17	Containment Isolation (#13,17)	No	N/A	N/A	No	No	No	No	No	No	Yes
Feedwater Heater Drains and Vents	1&2	47	No	None	No	N/A	N/A	No	No	No	No	No	No	No

Page 7 of 17

BGE

System Level Scoping Results

LCM-12 Revision 5

BGE LCM PROGRAM
TABLE 2
SYSTEM LEVEL SCOPING RESULTS

Revision 4

System/Structure	Unit	ID	Req'd for DBE (Criteria 1 & 2)	DBE Plant Function(s) (Criteria 1 & 2)	Q (Criteria 1 & 2)	Class I or SR-1M (Criteria 1 & 2)	Class I or SR-1M Reference (Criteria 1 & 2)	PAM (Criterion 3)	FP (Criterion 3)	ATWS (Criterion 3)	SBO (Criterion 3)	PTS (Criterion 3)	EQ (Criterion 3)	In Scope Yes/No
Docks and Marine Related Structures	Both	108	No	None	No	N/A	N/A	No	No	No	No	No	No	No
Barriers and Barrier Penetrations	Both	120	No	None	No	N/A	N/A	No	Yes	No	No	No	No	Yes
Auxiliary Building	Both	–	No. 19	Protection From Turbine-Generator Produced Missiles	No	Yes	UFSAR Chapter 5	No	Yes	No	No	No	No	Yes
Condensate Storage Tank #12 Enclosure	Both	–	No	None	No	Yes	UFSAR Chapter 5	No	No	No	No	No	No	Yes
Domestic Water Treatment Plant	Both	–	No	None	No	No	N/A	No	No	No	No	No	No	No
Engine Gen House	Both	–	No	None	No	No	N/A	No	No	No	No	No	No	No
Equipment Hatch Access Building #1	1&2	–	No	None	No	No	N/A	No	No	No	No	No	No	No
Equipment Hatch Access Building #2	1&2	–	No	None	No	No	N/A	No	No	No	No	No	No	No
Fire Protection Pump House	Both	–	No	None	No	No	N/A	No	No	No	No	No	No	No
Fuel Assemblies	1&2	–	No. 2 No. 3 No. 4 No. 5 No. 6 No. 7 No. 8 No. 9 No. 10 No. 12 No. 13 No. 14	Reactor Core Performance (All Req'd DBEs)	No	N/A	N/A	No	No	No	No	No	No	Yes

10A

Life Cycle Management Unit

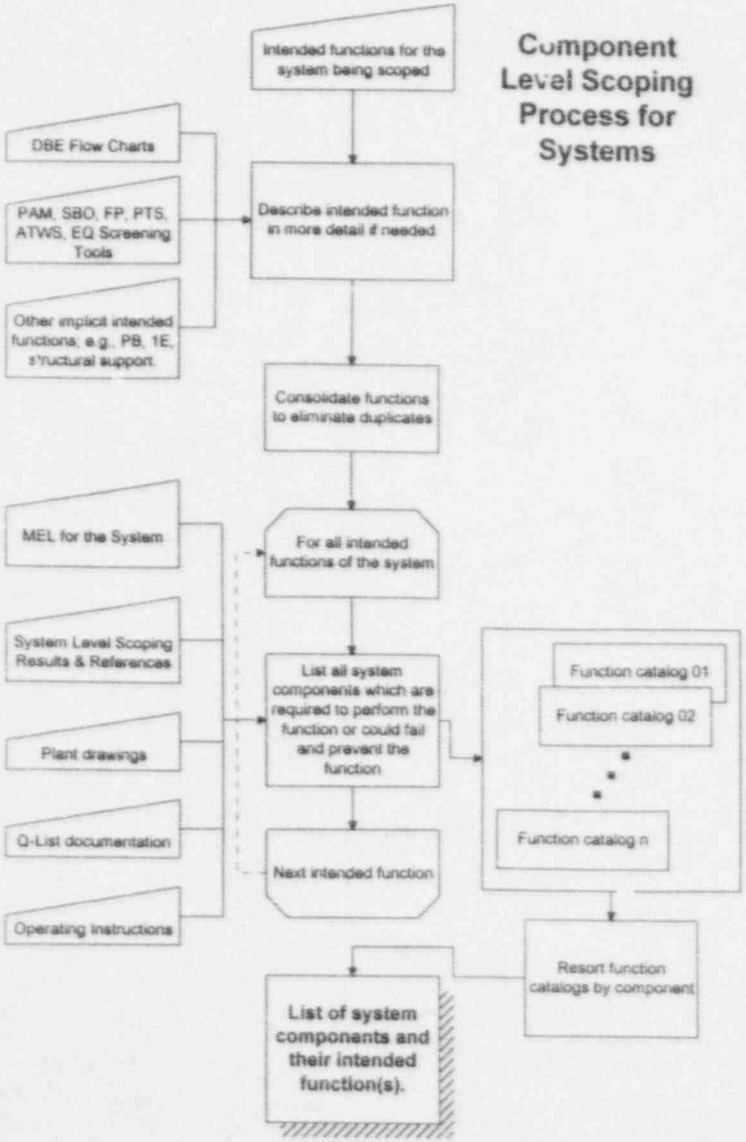


Figure 4-1

Component Level Scoping - Systems

- Methodology Section 4.1
- Steps
  - Identification of detailed system functions
  - Development of function catalogs
  - Generation of scoping results tables
- Results
  - Intended functions list
  - Function catalogs
  - Component Level Scoping Results

Table 1 - Intended Functions

BG&E LCM Program PAGE: 1

TABLE 1: ITLR SYSTEM FUNCTIONS REV. 1 DATE: 01/29/93

SYSTEM: 045 FEEDWATER

FUNCTION ID NUMBER	DESCRIPTION OF FUNCTION	QLIST ITLR Criteria 1 & 2 — DBE 2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	26	50	CLS1	PAM	Q	1E	1M	PB	Criterion 3 — EQ	PTS	ATWS	SBO	FP	4 — LCO
LR045-01	SEND SIGNALS TO ESFAS AND PROVIDE STEAM GENERATOR ISOLATION. (TPR 92-155 ADDRESSES THE APPLICABLE DBEs FOR THIS FUNCTION)												X	X																	
LR045-02	PROVIDE CONTAINMENT OVERPRESSURE PROTECTION.												X																		
LR045-03	PROVIDE CONTAINMENT ISOLATION.											X				X															
LR045-04	PREVENT REVERSE FLOW FROM SG VIA CLOSURE OF CHECK VALVE.																	X													
LR045-05	MAINTAIN FUNCTIONALITY OF ELECTRICAL EQUIPMENT AS ADDRESSED BY THE EQ PROGRAM.																									X					
LR045-06	TO MAINTAIN THE PRESSURE BOUNDARY OF THE SYSTEM LIQUID.																								X						
LR045-07	TO PROVIDE INFORMATION USED TO ASSESS THE PLANT AND ENVIRONS CONDITION DURING AND FOLLOWING AN ACCIDENT.																				X										
LR045-07-A	NOT USED																														
LR045-07-B	STEAM GENERATOR LEVEL.																														
LR045-07-C	STEAM GENERATOR PRESSURE. (TPR 92-155 REQUESTS THE ADDTION OF THIS PARAMETER)																														

Table 1 - Intended Function (page 2)

BG&E LCM Program

PAGE: 2

TABLE 1: ITLR SYSTEM FUNCTIONS

SYSTEM: 045 FEEDWATER

REV. 1

DATE: 01/29/93

		QLIST ITLR Criteria 1 & 2																								Criterion 3					4
		DBE																													
FUNCTION ID NUMBER	DESCRIPTION OF FUNCTION	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	26	50	CLS1	PAM	Q	1E	1M	PB	EQ	PTS	ATWS	SBO	FP	LCO
LR045-08	PROVIDE STEAM GENERATOR LEVEL INDICATION.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
LR045-09	TO MAINTAIN ELECTRICAL CONTINUITY AND/OR PROVIDE PROTECTION OF THE ELECTRICAL SYSTEM.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
LR045-10	PROVIDE CLOSURE OF CONTAINMENT ISOLATION VALVES. (TPR 92-155 WRITTEN TO DELETE THIS FUNCTION)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
LR045-11	PROVIDE SIGNALS TO AFAS.	X	X	X	X	X	X	.	X	X	X	X	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
LR045-12	PROVIDE SIGNALS TO RPS.	.	.	X	.	X	X	.	.	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.

BGE

Life Cycle Management Unit

Function Catalog - LR045- 06 Pressure Boundary

BG&E CCNPP ITLR COMPONENT FUNCTION CATALOG

Revision: 1

EXTRACT DATE: 11/04/92
REPORT DATE: 01/29/93
PAGE NUMBER: 1

FUNCTION: LR045-06
SYSTEM: 045

EQUIPMENT ID	REFERENCE	NOTES
1#DB1-1018	NETD	1
1#DB1-1019	NETD	1
.#DB3-1001	NETD	1
1#DB3-1002	NETD	1
1CKVFW-130	NETD	1
1CKVFW-133	NETD	1
1HVFW-1501	NETD	1
1HVFW-1502	NETD	1
1HVFW-1503	NETD	1
1HVFW-1504	NETD	1, TPR 92-144
1HVFW-1505	NETD	1
1HVFW-1506	NETD	1
1HVFW-1507	NETD	1
1HVFW-1508	NETD	1
1HVFW-1510	NETD	1
1HVFW-1511	NETD	1
1HVFW-1512	NETD	1
1HVFW-1513	NETD	1
1HVFW-1514	NETD	1
1HVFW-1517	NETD	1

BGE

Life Cycle Management Unit

Component Level Scoping Results

BG&E Life Cycle Management Program PAGE: 78

TABLE 2: ITLR COMPONENT LEVEL SCREENING RESULTS

SYSTEM: 045 FEEDWATER

DATE: 01/28/93

NUC'F'S EXTRACT DATE: 11/04/92

REVISION: 1

EQUIPMENT ID	EQUIPMENT DESCRIPTION	FUNCTION ID (REF TABLE 1)	REFERENCE	ITLR LR OR N	NOTE
			FLWSHT-103C	LR	
		LR045-03	UFSAR Ch5 Fg10 Sh22	LR	
		LR045-06	NETD	LR	
1MOV4516OP	11 SG FW ISOL	LR045-01	FLWSHT-103C	LR	
			FLWSHT-103B	LR	
			FLWSHT-103A	LR	
			FLWSHT-136	LR	
		LR045-02	FLWSHT-103C	LR	
		LR045-03	UFSAR Ch5 Fg10 Sh22	LR	
		LR045-05	NETD	LR	
1MOV4517	12 SG FW ISOL	LR045-01	FLWSHT-103C	LR	
			FLWSHT-103B	LR	
			FLWSHT-103A	LR	
			FLWSHT-136	LR	
		LR045-02	FLWSHT-103C	LR	
		LR045-03	UFSAR Ch5 Fg10 Sh22	LR	
		LR045-06	NETD	LR	
1MOV4517OP	12 SG FW ISOL OPER	LR045-01	FLWSHT-103C	LR	
			FLWSHT-103B	LR	
			FLWSHT-103A	LR	
			FLWSHT-136	LR	
		LR045-02	FLWSHT-103C	LR	
		LR045-03	UFSAR Ch5 Fg10 Sh22	LR	
		LR045-05	NETD	LR	
1MOV5087	11 SGFP HP STOP ABOVE SEA			N	
1MOV5087OP	11 FW SGFP HP STOP ABOVE			N	
1MOV5088	11 SGFP HP STOP BELOW SEA			N	
1MOV5088OP	11 FW SGFP HP STOP BELOW			N	

Figure 4-2

Component Level Scoping - Structures

- Methodology Section 4.2
- Steps
  - Function identification
  - Generic Structure Component Types
  - Structural components which contribute to intended functions
- Results
  - Tbl 1S Structure Intended Functions
  - Tbl 2S Structural Components that are part of the structure
  - Tbl 3S Structural components within the scope of LR

BGE

Life Cycle Management Unit

Table 1S

BG&E LCM PROGRAM						LCM-11S REV. 1
TABLE 1S: STRUCTURE INTENDED FUNCTIONS						Rev. 1 Date: 3/20/96
STRUCTURE: AUXILIARY BUILDING						SHEET 2 OF 2
INTENDED FUNCTION ID NUMBER	DESCRIPTION OF INTENDED FUNCTION	CRITERIA				APPLICABLE TO THIS STRUCTURE? Yes/No
		1	2	3	4	
LR-S-01	Provides structural and/or functional support to safety-related equipment	X				Yes
LR-S-02	Provides shelter/protection to safety-related equipment	X				Yes
LR-S-03	Serves as a pressure boundary or fission product retention barrier to protect public health and safety in the event of any postulated DBEs	X				Yes
LR-S-04	Serves as a missile barrier (internal or external)	X				Yes
LR-S-05	Provides structural and/or functional support to non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions		X			Yes
LR-S-06	Provides flood protection barrier (internal flooding event)		X			Yes
LR-S-07	Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant			X		Yes

Table 2S - Concrete

BG&E LCM PROGRAM			LCM-11S REV. 1
TABLE 2S STRUCTURAL COMPONENTS THAT ARE PART OF THE STRUCTURE			Rev. 1 Date: 3/20/96
STRUCTURE: AUXILIARY BUILDING			SHEET 2 OF 5
COMPONENT	In Structure Yes/No	In Structure Reference	Remarks/Reference(s)
A. Concrete (including Reinforcing Steel)			
1. Foundations (Footings, Beams, and Mats)	Yes	61-666, 61-668 thru 61-671	
2. Columns	Yes	61-666, 61-670, 61-671, 61-675, 63-675, 61-680, 63-680, 61-693 thru 696, 61-719	
3. Walls	Yes	61-666, 61-670, 61-671, 61-675, 63-675, 61-680, 63-680, 61-685, 63-685	
4. Beams	Yes	61-979, 61-980, 61-714, 61-715, 61-996	
5. Ground Floor Slabs and Equipment Pads	Yes	61-680, 63-680, 61-991	See D.6 this table
6. Elevated Floor Slabs	Yes	61-670, 61-671, 61-675, 63-675, 61-680, 63-680, 61-685, 63-685, 62-149 through 62-153	
7. Roof Slabs	Yes	61-685, 63-685, 61-690	
8. Cast-In-Place Anchors	Yes	61-670, 61-671, 61-973, 61-991, 63-502, 63-503	
9. Manholes	No		
10. Duct Banks	No		
11. Grout	Yes	61-666, 63-510, 63-512, 63-522	
12. Concrete Blocks (Shielding)	Yes	63-884, 61-670, 63-511	
13. Precast Concrete	No		
14. Fluid Retaining Walls and Slabs	Yes	61-706, 61-707, 61-708	
15. Masonry Block Walls	Yes	62-128, 62-172 thru 62-176	
16. Post-Installed Anchors (Expansion and Grouted Types)	Yes	61-670, 61-671	

BGE

Life Cycle Management Unit

Table 3S - Structural Steel

BG&E LCM PROGRAM			LCM-11S REV. 1
TABLE 3S: STRUCTURAL COMPONENTS WITHIN THE SCOPE OF LICENSE RENEWAL			Rev. 1 Date: 3/20/96
STRUCTURE: AUXILIARY BUILDING			SHEET 3 OF 10
Component	Intended Function Number LR-S-	Intended Function Description	Remarks/References
B. Structural Steel			
1. Columns	1,5	See Note S-1	
2. Beams	1,5	See Note S-2	
3. Base Plates	1,5	See Note S-3	
4. Floor Framing	1,5	See Note S-4	
5. Roof Framing	1,4,5	See Note S-5	
6. Roof Trusses	1,4,5	See Note S-6	
7. Bracing	1,5	See Note S-7	
8. Girts	N/A		Component not within the scope of LR
9. Platform Hangers	1,5	See Note S-9	
10. Decking	1,5	See Note S-10	
11. Jet Impingement Barriers	2	See Note S-11	
12. Light Poles	—		Component not in structure
13. Steel Liners	3	See Note S-13	
14. Light-Gage Metal Buildings	—		Component not in structure
15. Floor Grating	N/A		Component not within the scope of LR
16. Checkered Plate	N/A		Component not within the scope of LR
17. Stairs and Ladders	N/A		Component not within the scope of LR
18. Lintels	—		Component not in structure

BGE

Table 3S - Unique Components

BG&E LCM PROGRAM			LCM-11S REV. 1
TABLE 3S: STRUCTURAL COMPONENTS WITHIN THE SCOPE OF LICENSE RENEWAL			Rev. 1 Date: 3/20/96
STRUCTURE: AUXILIARY BUILDING			SHEET 5 OF 10
Component	Intended Function Number LR-S-	Intended Function Description	Remarks/References
D. Additional Components			
1. Watertight doors	6,7	See Note SP-1	
2. Lead Brick Shielding	2	See Note SP-2	
3. Roll-up Doors	2	See Note SP-3	
4. New Fuel Rack Assembly	1	See Note SP-4	
5. Monorail	5	See Note SP-5	
6. Equipment Pads			
a. Control Room HVAC Equipment Room	1,5	See Note SP-6	See Table 4
b. Emergency Diesel Generator Rooms	1,5	See Note SP-6	See Table 4
c. Charging Pumps Rooms	1,5	See Note SP-6	See Table 4
d. ECCS Pump Rooms	1,5	See Note SP-6	See Table 4
e. Switchgear & Electrical Equipment Rooms	1,5	See Note SP-6	See Table 4
f. Component Cooling Pump Rooms	1,5	See Note SP-6	See Table 4
g. Service Water Pump Rooms	1,5	See Note SP-6	See Table 4
7. Cask Handling Crane Rail/supports	1,5	See Note SP-7	
8. Pipe Whip Restraints	2	See Note SP-8	
9. Expansion Joints	2, 7	See Note SP-9	
10. Spent Fuel Storage Racks	1	See Note SP-10	

Pre-Evaluation

- **Methodology Section 5**
- **Steps**
  - Categorized intended functions as active or passive.
  - Determine long-lived or short-lived.
  - Determine whether components will be covered by a commodity evaluation.
  - Exclude components specifically excluded by LR Rule.
- **Results**
  - List of SCs subject to AMR.

Pre-Evaluation Process

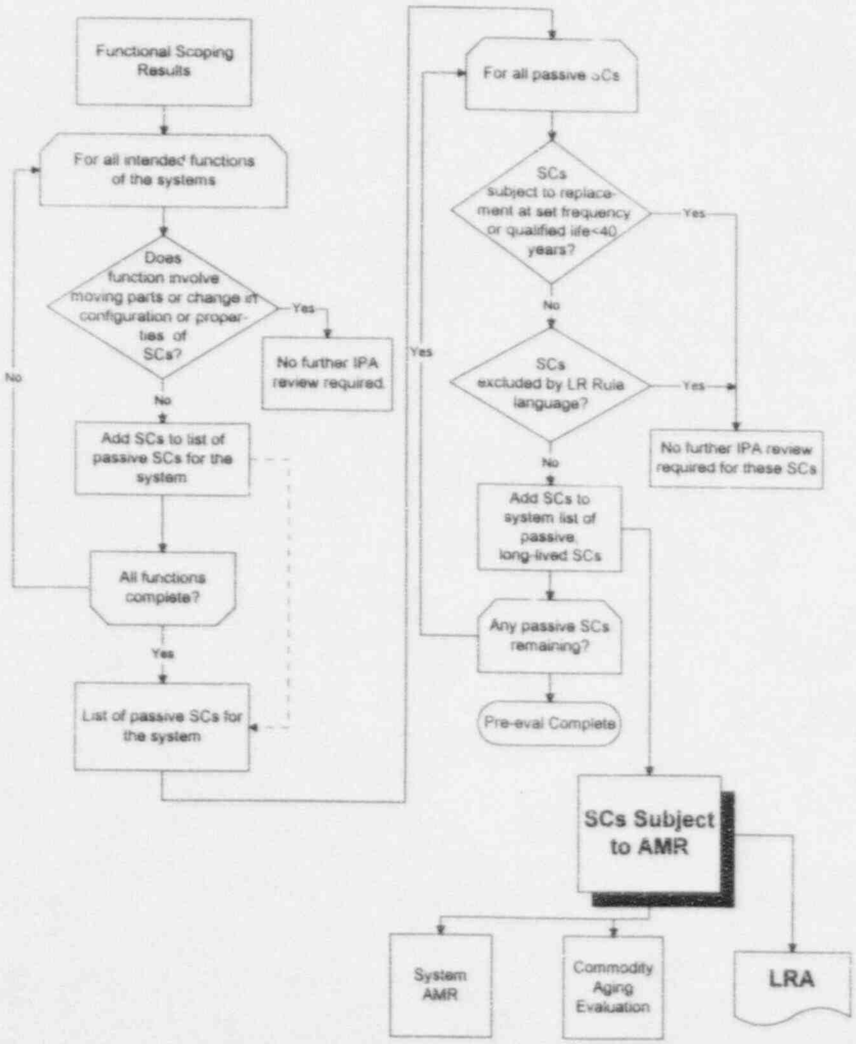


Figure 5-1

Pre - Evaluation Results

ATTACHMENT 4, COMPONENTS SUBJECT TO SYSTEM AGING MANAGEMENT REVIEW

Component Pre-Evaluation Revision 1

System: Main Feedwater (045) Date: March 7, 1996

Equipment ID	Equipment Description
1-DB1-1018	FW SYSTEM PIPING
1-DB1-1019	FW SYSTEM PIPNG
1-DB3-1001	FW SYSTEM PIPING
1-DB3-1002	FW SYSTEM PIPING
1CKVFW-130	12 SG FW HDR CKV
1CKVFW-133	11 SG FW HDR CKV
1HVFW-1501	LT-1113A ROOT
1HVFW-1502	LT-1113A ROOT
1HVFW-1503	LT-1113A ROOT
1HVFW-1504	LT-1113A ROOT
1HVFW-1521	LT-1113B ROOT
1HVFW-1522	LT-1113B ROOT
1HVFW-1523	LT-1113B ROOT
1HVFW-1524	LT-1113B ROOT
1HVFW-1541	LT-1113C ROOT
1HVFW-1542	LT-1113C ROOT
1HVFW-1543	LT-1113C ROOT
1HVFW-1544	LT-1113C ROOT
1HVFW-1561	LT-1113D ROOT
1HVFW-1562	LT-1113D ROOT
1HVFW-1563	LT-1113D ROOT
1HVFW-1564	LT-1113D ROOT
1HVFW-1587	1-LT-1114A ROOT VLV
1HVFW-1588	1-LT-1114A ROOT VLV
1HVFW-1596	1-LT-1114B ROOT VLV
1HVFW-1597	1-LT-1114B ROOT VLV
1HVFW-1601	LT-1123A ROOT
1HVFW-1602	LT-1123A ROOT
1HVFW-1603	LT-1123A ROOT
1HVFW-1604	LT-1123A ROOT
1HVFW-1621	LT-1123B ROOT
1HVFW-1622	LT-1123B ROOT
1HVFW-1623	LT-1123B ROOT
1HVFW-1624	LT-1123B ROOT
1HVFW-1641	LT-1123C ROOT
1HVFW-1642	LT-1123C ROOT
1HVFW-1643	LT-1123C ROOT
1HVFW-1644	LT-1123C ROOT
1HVFW-1661	LT-1123D ROOT
1HVFW-1662	LT-1123D ROOT
1HVFW-1663	LT-1123D ROOT
1HVFW-1664	LT-1123D ROOT
1HVFW-1687	1-LT-1124A ROOT VLV
1HVFW-1688	1-LT-1124A ROOT VLV

BGE

Pre - Evaluation Results

ATTACHMENT 4A, COMPONENTS SUBJECT TO COMMODITY AGING MANAGEMENT REVIEW

Component Pre-Evaluation Revision 1

System: Main Feedwater (045)

Date: March 7, 1996

Instrument Lines Commodity Evaluation	
Equipment ID	**Equipment Description**
1HVFW-1505	LT-1113A HI VENT
1HVFW-1506	LT-1113A DRN
1HVFW-1507	LT-1113A ISOL
1HVFW-1508	LT-1113A ISOL
1HVFW-1510	1105-LT ISOL
1HVFW-1511	LT-1113A EQUAL
1HVFW-1512	LT-1113A B/U DRN
1HVFW-1513	LT-1113A DRN
1HVFW-1514	LT-1113A B/U DRN
1HVFW-1517	1105-LT ISOL
1HVFW-1518	1105-LT ISOL
1HVFW-1519	1105-LT DRN
1HVFW-1520	1105-LT DRN
1HVFW-1525	LT-1113B HI VENT
1HVFW-1526	LT-1113B DRN
1HVFW-1527	LT-1113B ISOL
1HVFW-1528	LT-1113B ISOL
1HVFW-1530	1-LT-1111 ISOL
1HVFW-1531	LT-1113B EQUAL
1HVFW-1532	LT-1113B B/U DRN
1HVFW-1533	LT-1113B DRN
1HVFW-1534	LT-1113B B/U DRN
1HVFW-1537	1-LT-1111 ISOL
1HVF[illegible]38	1-LT-1111 ISOL
1HV[illegible]539	1111-LT DRN
1HVFW-1540	1111-LT DRN
1HVFW-1545	LT-1113C HI VENT
1HVFW-1546	LT-1113C DRN
1HVFW-1547	LT-1113C ISOL
1HVFW-1548	LT-1113C ISOL
1HVFW-1550	1105-LT B/U DRN
1HVFW-1551	LT-1113C EQUAL
1HVFW-1552	LT-1113C B/U DRN
1HVFW-1553	LT-1113C DRN
1HVFW-1554	LT-1113C B/U DRN
1HVFW-1557	1105-LT B/U DRN
1HVFW-1565	LT-1113D HI VENT
1HVFW-1566	LT-1113D DRN
1HVFW-1567	LT-1113D ISOL
1HVFW-1568	LT-1113D ISOL
1HVFW-1570	1111-LT B/U DRN
1HVFW-1571	LT-1113D EQUAL

Scoping and Commodity Evaluations

IPA Flow Diagram

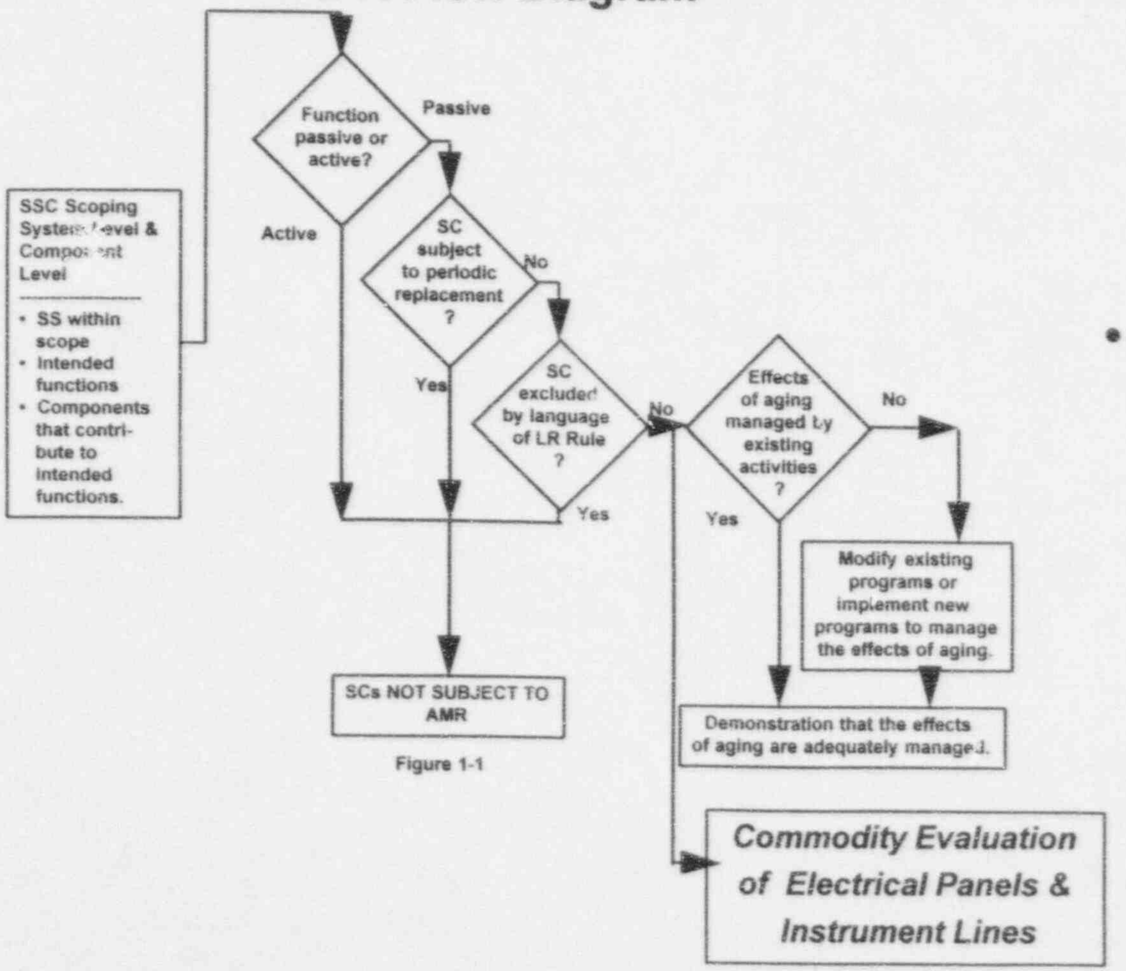
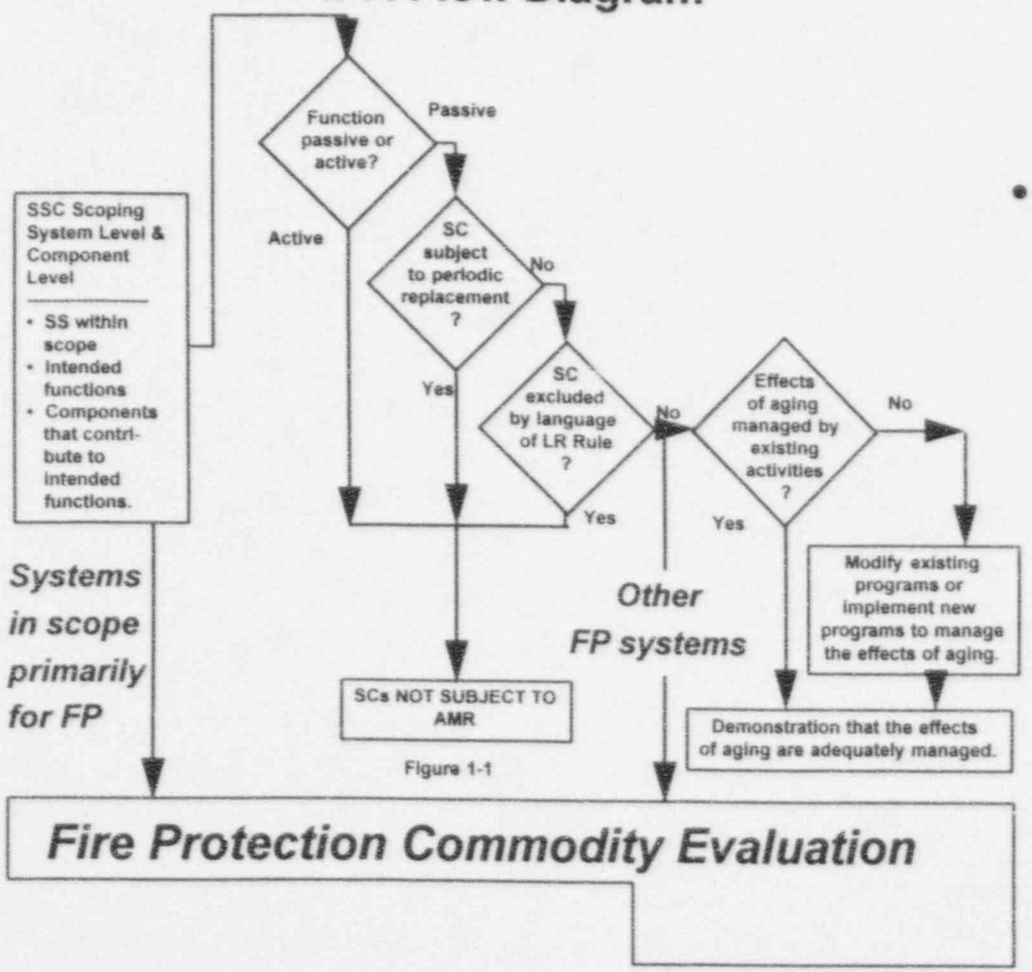


Figure 1-1

- *For electrical panels and instrument lines evaluations,*
  - *the commodity evaluation replaces only the AMR step of the IPA.*
  - *Scoping/pre-eval are done per the standard process.*

Scoping and Commodity Evaluations (Cont.)

IPA Flow Diagram

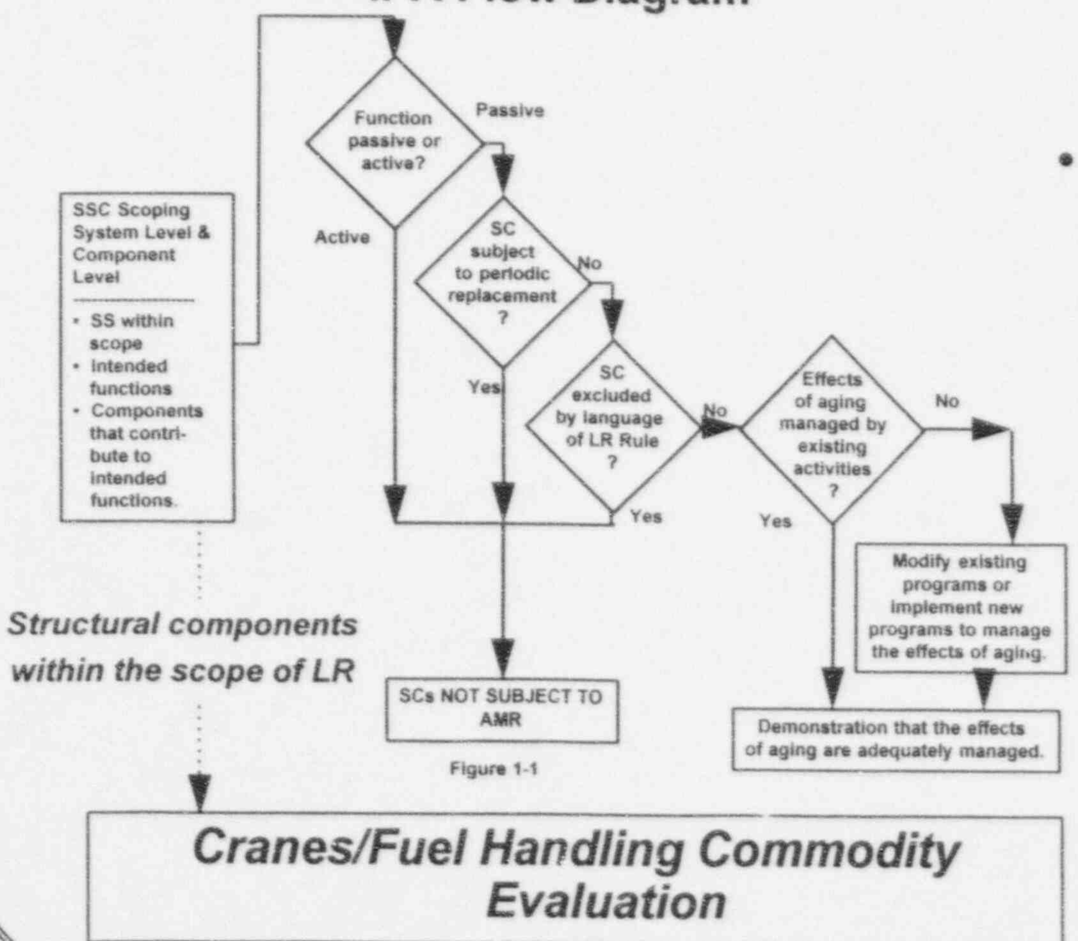


- *For the FP commodity evaluation*
  - *Systems in scope primarily for FP function were scoped & pre-eval'd as part of the commodity eval.*
  - *Other systems with FP functions were scoped/ pre-eval'd using the standard process.*

BGE

Scoping and Commodity Evaluations (Cont.)

IPA Flow Diagram



- *For the Cranes/Fuel Handling commodity evaluation*
  - *Systems associated with load handling/ refueling were scoped as part of comm eval.*
  - *Structures component level scoping results were reviewed to ensure proper interfaces.*

Scoping and Commodity Evaluations (Cont.)

IPA Flow Diagram

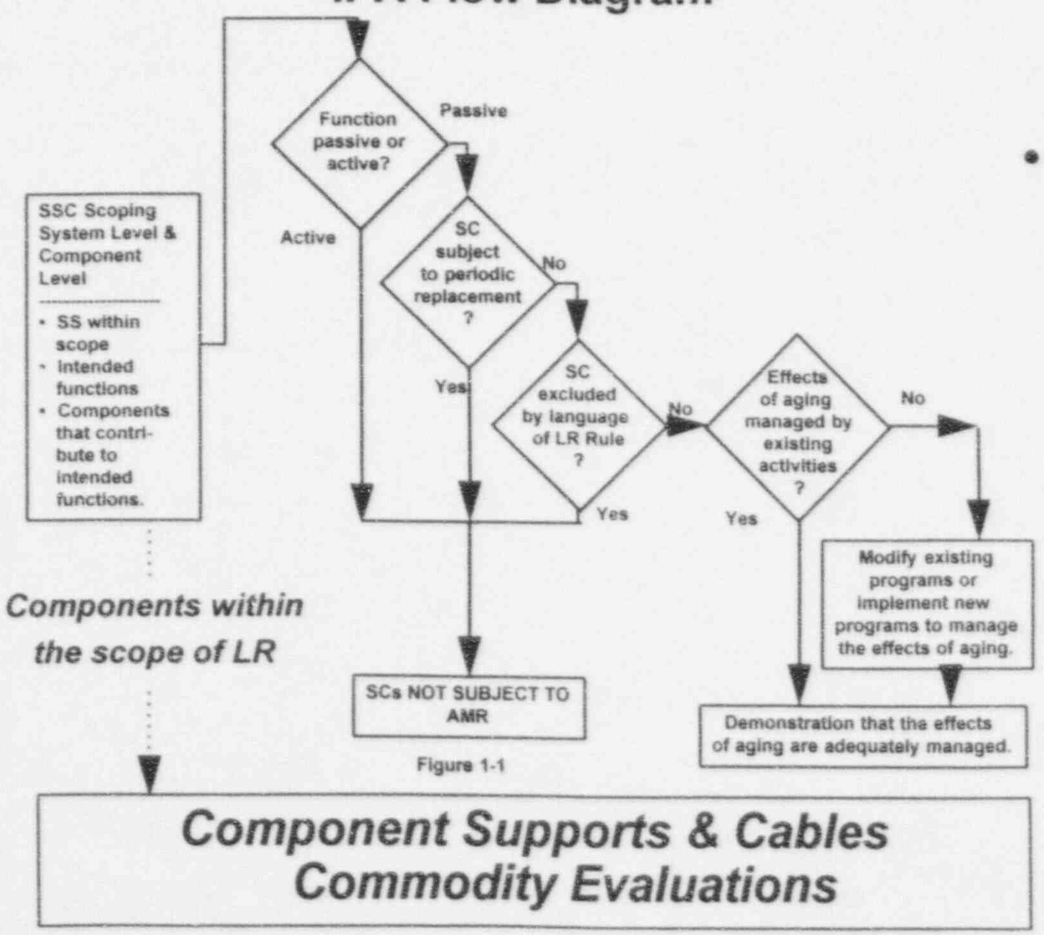


Figure 1-1

- *For the Cables & Component Supports commodity evaluations*
  - *Commodity evaluation covered all steps of the IPA.*
  - *Scoping step was closely linked to scoping results for supported components and electrical loads.*

Piping Design & Analysis at Calvert Cliffs Nuclear power Plant

By Todd Conner
Oct. 10, 1996

Purpose

- Identify what the current licensing basis requirements are for piping at CCNPP
- Identify Piping Design Engineering Capabilities at CCNPP

Design Codes at CCNPP

- B31.7 1969 - autumn '71
  - » Class 1 Systems
  - » Class 2 systems off the RCS (Typically)
- B31.1 1967 - summer '72
  - » Class 3 systems
- Section III 1965 winter '67
  - » NSSS Vessels
- Section III 1977 summer '78
  - » Third Train AFW (Added after constr.)

System vs. Code

- Class 1 systems
  - » Reactor Coolant System (B31.7 Class I)
  - » RCS Attached Piping (B31.7 Class I)
    - – Safety Injection
    - – Letdown/Charging
    - – Pressurizer Spray/ Aux... Spray
    - – NSSS Sampling System
    - – Surge Line
    - – Safety Valve Lines

System vs. Code

- Class 2 systems
  - » Feed Water (B31.1)
  - » Charging / Letdown / Boric Acid (B31.1)
  - » ECCS - LPSI, HPSI, CS, SDC (B31.7 Cl II)
  - » AFW (B31.1)
- Class 3 systems
  - » Service Water, Comp. Cooling Water, SaltWater (B31.1)
  - » AFW Motor Driven (Section III)
  - » Spent Fuel Pool Cooling (B31.7 Class III)

UFSAR Requirements

- Chapter 4 (Class I)
- Chapter 5A (all seismic)
- Figures 5A-6 and 4-8 (specific load combinations & limits)

Seismic Basis for Piping

- Cat. I Structures (UFSAR Ch 5A)
  - » Response Curves
  - » Damping Values
  - » Code Case N-411

TABLE 5A-6

TABLE OF LOADING COMBINATIONS AND PRIMARY STRESS LIMITS FOR NUCLEAR CLASS 2 AND 3 PIPING

LOADING COMBINATIONS	PRIMARY STRESS LIMITS: Vessels	Piping	Supports
1. Design Loading + OBE	$P_M \leq S_H$	$P_M \leq 1.2\, S_h$	Working Stress
	$P_B + P_L \leq 1.5\, S_H$	$P_B + P_M \leq 1.2\, S_h$	
2. Normal Operating Loadings + Safe Shutdown + Earthquake	$P_M \leq S_D$	$P_M \leq S_D$	Within Yield
	$P_B \leq 1.5 \left[1 - \frac{(P_M)^2}{(S_D)^2}\right] S_D$ (b)	$P_B \leq \frac{4}{\pi} S_D \operatorname{Cos}\left(\frac{\pi}{2} \bullet \frac{P_M}{S_D}\right)$ (c)	
3. Normal Operating Loadings + Pipe Rupture + Safe Shutdown Earthquake	$P_M \leq S_L$	$P_M \leq S_L$	Deflection of supports limited to maintain supported equipment within limits shown in columns (1) and (2)
	$P_B \leq 1.5 \left[1 - \frac{(P_M)^2}{(S_L)^2}\right] S_L$ (b)	$P_B \leq \frac{4}{\pi} S_L \operatorname{Cos}\left(\frac{\pi}{2} \bullet \frac{P_M}{S_L}\right)$ (a),(c)	

(a) These stress criteria are not applied to the piping run within which a pipe break is considered to have occurred

(b) For loading combinations 2 and 3, stress limits for vessel, with symbol P_M changed to P_L, should also be used evaluating the effects of local loads imposed on vessels and/or piping.

(c) The tabulated limits for piping are based on a minimum "shape factor." These limits may be modified incorporate the shape factor of the particular piping being analyzed.

dynamic earth pressure as well as static earth pressure (Section 2.7.6.4).

5A.3.1.14 Design Code References

The design and checking of the design have been made in accordance with the provisions indicated in the ACI Code and Commentary 318-63, Section 2603(a), 2603(b) and ACI Committee 334 (Concrete Shell Structures Practice and Commentary), Section 202(d), 202(e) and Commentary Part 4, except as modified in Updated Final Safety Analysis Report Section 5.1.2.3 through 5.1.2.6 and Section 5.1.3.2.

5A.3.2 SEISMIC CATEGORY I SYSTEMS AND EQUIPMENT DESIGN

Seismic Category I systems and equipment, including pipe, are designed to meet the load combinations and stresses as stated in Table 4-8 for Nuclear Class 1, and Table 5A-6 for Nuclear Class 2 and 3, and non-class. Seismic Category I systems and equipment are bolted down rigidly to supports or braced (as in the case of cable tray supports) to resist seismic and tornado forces. The NSSS contractor is taking exception to this support approach and the individual supports were designed based on the criteria outlined in Sections 5.1.1 and 5.1.2.8. There are no significant gaps between the equipment and their supports or restraints. Any small gap will not cause significant impact forces on the equipment, restraints or the structures. Therefore, small gaps between the equipment and supports or restraints are not significant in the consideration of the seismic analysis.

Deformations in support structures will limit strains in piping systems to the criteria stated in Tables 4-8 and 5A-6 for those systems essential to safe shutdown of the plant following a LOCA.

The Containment penetration assemblies are designed to accommodate the forces and moments due to pipe rupture. Guides, pipe stops, increased pipe thicknesses or other means are provided to make the penetration the strongest part of the system.

The mathematical models employed in dynamic (seismic) analysis of the Reactor Coolant System components were formulated using lumped

parameter modeling techniques. A single composite model was employed in the analysis of the couple components, which included the reactor vessel assembly, the two steam generators, the four reactor coolant pumps and the reactor coolant piping. The total mass and related stiffness of each of the coupled components was included in the model. Sufficient mass points were included in the model and, at each mass point, translational dynamic degrees of freedom retained, so dynamic analysis includes the combined vertical, torsional and horizontal response of the system due to seismic excitations.

A separate multi-mass model was employed in the seismic analysis of the pressurizer.

5A.3.2.1 Piping

For the design of Seismic Category I piping and equipment, coefficients were based on the floor response-spectrum curves. These curves were generated using the time-history technique for both horizontal and vertical direction, for various damping values, and at designated floor elevations in the Category I structures. This method is based on a dynamic analysis of multi-degree-of-freedom system. Code Case N-411 of the ASME B&PV Code may be used to take advantage of the flexibility in piping systems (Section 5A.3.2.2).

Buried Pipes

All Category I buried pipes are designed for bending stresses due to ground motion. At the joints, where direction of pipe changes, a cushion of compressible material is provided to accommodate any rotation of the pipe joint.

Above-Ground Pipes

Piping systems are anchored and restrained to floors and walls of buildings. The relative seismic displacements between buildings, between floors in buildings, and between major components are applied to the piping, anchors and restraints. Seismic movements are always considered to be out of phase between buildings, hence maximum relative

displacements are used. The resulting stresses are classified as secondary and are combined with other secondary stresses. The sum of secondary stresses is held within the limits of the applicable piping code.

5A.3.2.2 Routing of Seismic Category I Piping

The routing of all Category I piping is confined within the Containment Structure or the Auxiliary Building, both of which are Category I structures. Category II piping such as instrument and plant air, plant heating system water, nitrogen, wash water service, fire protection, and roof drain lines are primarily 2" and smaller piping. The 2" and smaller Category II pipe runs which are routed in close proximity of Category I piping do not have the potential to inflict damage on the Category I piping. Physical separation of larger Category II piping is routed such that its failure would not pose a hazard. Where larger Category II piping whose rupture could pose a hazard is routed near Category I piping, adequate pipe restraints are provided to preclude the possibility of pipe whip damage to the Category I piping.

Category I piping was designed in accordance with B31.1 1967, Power Piping, or B31.7 1969, Nuclear Power Piping. Exceptions are noted in relevant sections of the UFSAR for specific systems and components. Effective August 6, 1985, ASME Code Case N-411, "Alternative Damping Values for Seismic Analysis of Piping, Section III Div. 1 Class 1, 2 and 3 Construction," may be used for new analyses or for reconciliation work on new or existing systems. This case takes advantage of piping system flexibility. See the provisions in the NRC letter dated August 6, 1985, when using this code case. All Category I piping, with the exception of 2" and smaller B31.1 and B31.7 Nuclear Class 2 and 3 piping, was originally designed by Bechtel Power Corporation and included the location of restraints and supports, and determination of loads. The building structure connections were checked by the structural engineering group. The piping support contractor was given all necessary information to design and locate pipe supports, and indicates the location

of the supports on Bechtel's piping fabrication isometric erection sketch. These drawings, as well as the support design drawings and field installation were checked by Bechtel Engineering. For 2" and smaller Category I piping, a Bechtel field installation manual was provided so that field engineers could properly design and locate pipe supports and restraints. When Bechtel field engineers had completed their design, drawings were submitted to Bechtel engineering for review. The field did not locate any of the seismic supports or restraints for Category I system equipment or components. This work was done at the CE and Bechtel engineering offices.

5A.3.2.3 Equipment, Personnel, and Escape Locks

The equipment, personnel and escape locks are Category I equipment and are designed for the following accelerations: (OBE)

Lock	Vertical Acceleration	Horizontal Acceleration
Equipment Lock	0.07 g	0.11 g
Personnel Lock	0.08 g	0.12 g
Escape Lock	0.07 g	0.10 g

The acceleration values are multiplied by the normal operating weight of the lock or parts of the lock to obtain the horizontal and vertical components of the earthquake force. Both components are considered acting simultaneously with normal operating loads without exceeding code allowable, at a temperature of 120°F.

The earthquake forces due to the SSE are obtained by multiplying the accelerations above by 1.90. The locks are designed to withstand the simultaneous action of SSE components and accident loads as stated in Chapter 5, at a temperature of 276°F, without exceeding material yield stress nor loss-of-lock function.

5A.3.1.6 Amplified Response Loading for Piping and Instrumentation

A multi-mass response-spectrum, modal analysis method was employed in the seismic analysis of Category I piping, support systems and instrumentation. American Society of Mechanical Engineers (ASME) Code Case N-411 may be used to take advantage of the flexibility in piping systems (Section 5A.3.2.2). The natural frequencies, mode shapes, and the maximum response accelerations were determined using the appropriate response-spectrum curves in the horizontal and vertical direction. The response-spectrum curves are generated using the time-history of the floor, which includes the seismic response of the building. The horizontal and vertical seismic forces were applied simultaneously. Shear stresses, moments, and deflections were determined for the piping system and restraints. The load and stresses due to

seismic loadings were assumed to be acting simultaneously with operating weights and longitudinal pressure loads.

	% Critical Damping (translational)	
	"OBE" (E)	"SSE" (E')
Welded steel plate assemblies	1	1
Welded steel framed structures	2	2
Bolted or riveted steel framed structures	2.5	2.5
Reinforced concrete equipment supports	2	3
Reinforced concrete frame and buildings	3	5
Prestressed concrete structures	2	5
Steel piping	0.5	0.5
Soil	2	3

	% Critical Damping (rotational)	
	(E)	(E')
Rocking motion for prestressed concrete structures	5	7
Rocking motion for reinforced concrete structures	5	7

Load Combinations & Stress Limits

- ES-040 is a formal Design Document that provides design criteria that ensures the compliance with CCNPP UFSAR, and CLB for:
  - » Piping
    - – (Loads, combinations, and Stress Criteria)
  - » Supports
    - – (Loads, combinations, and Stress Criteria)
  - » Attachments to Equipment and structures

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 3 of 7)

2. LOAD DESCRIPTIONS

A. **Weight**

Weight of the piping system will include the weight of the pipe material, attached insulation or shielding, attached or inline piping components, and the weight of the fluid within. The design weight is the maximum weight of the system, e.g., when the system is completely filled with water. For those piping systems which do not operate with a liquid, e.g., steam piping, an additional weight analysis may be necessary to calculate the system loading for the hydrodynamic pressure test condition. Treat this as a test load (see code for pipe and support limits).

B. **Pressure**

The pressure used for any load case should be appropriate to the operating or transient condition being analyzed. The design, normal, and maximum pressures are listed in M-601 for each system service number.

C. **Temperature Effects**

Temperature effects will include thermal expansion/contraction of the pipe, and anchor movements imposed by the thermal movement of equipment to which the pipe is attached. In an extreme case, anchor movements from containment expansion during a LOCA will also be included.

If an analysis is performed and thermal movements are found to be excessive, these movements should be checked for interference.

All frame-type supports classified as "rigid" should be evaluated for the sliding friction force resulting from thermal growth in the longitudinal direction of the supported pipe. This friction effect should only be evaluated for normal operating loads (i.e., do not combine with transient loads or OBE/SSE). In general, the friction force should be computed as 0.3 x (weight + radial forces from thermal expansion, where applicable) and applied in the direction of thermal growth. Other approaches to evaluating frictional affects may be used if properly justified or referenced.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 4 of 7)

D. **Fluid Transient**

Fluid transients are dynamic events associated with irregular flow or interrupted flow in the pipe. Fluid hammer may result from rapid valve closure. Fluid slug results from an amount of liquid water being propelled at high speed (either by the sudden opening of a valve on a line under pressure, or the venting of steam into a closed discharge system that contained water) impacting an elbow, pipe bend, or pipe terminal end. These events are usually evaluated by time-history methods.

E. **Relief/Safety Valve Discharge**

When a relief or safety valve discharges, the fluid initiates a jet force that is transferred through the piping system. If the valve vents to atmosphere, the jet force may be calculated and applied to the system as a constant load. If the valve vents to a closed discharge system, transient conditions may develop (such as the generation of a fluid slug) which may require time-history analysis.

F. **Earthquake Effects**

Seismic Category I piping systems must be designed to resist two levels of earthquake: OBE and SSE. Earthquakes will generate two types of loads applicable to piping systems: inertia loads (from the excitation of the piping system's mass) and anchor movement loads (from the movement of equipment or structures to which the piping system is attached).

Use the response spectrum method for the seismic analysis of piping systems, unless alternative techniques, i.e., time-history analysis are approved. The spectrum provides values of acceleration (response) plotted against natural frequency for a series of damping values and a ductility value of one. Code Case N-411 damping may be used for all new or revised piping system analyses. If spectra for the SSE are not available, they may be calculated by using SSE = 1.875 OBE (the ratio for the vertical response of containment is less in several cases).

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 5 of 7)

When analyzing a system for the effects of seismic inertia ensure that all values of acceleration are enveloped for the entire frequency range. The following guidelines may be useful, but requires verification that all peaks are enveloped:

- For systems that run between floor levels, select the most conservative floor response spectrum.
- For systems that go between seismically-independent structures, use the most conservative building and elevation spectrum.

Use the SRSS approach for modal combinations and treat closely-spaced modes as addressed in AEC Reg. Guide 1.92. Total response to the three directions of motion (N-S, E-W, vertical) should also be obtained by the SRSS approach.

Evaluate seismic anchor movement for the piping system if one or more of the following exist:

- The piping system is run between two seismically independent structures.
- The piping is attached to large equipment or internal structures which have the capability for independent motion.
- The difference in elevation between the highest anchor point and the lowest anchor point on the piping system is greater than 40 feet and the net relative displacement between the two points is greater than 1/16th inch.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 6 of 7)

Seismically independent structures include the following:

- Main auxiliary building (upper elevations have separate east/west structures).
- Penetration area (auxiliary building).
- Diesel generator rooms (11, 12, 21, 22).
- Containment building.
- Intake structures (pumphouse, divided into north/middle/south substructures).

Equipment and internal structures having the capability for independent motion are:

- Containment internal structure (floors are fixed to internal structures, and slotted at shell).
- Reactor vessel.
- Reactor coolant pumps.
- Reactor coolant loop, pressurizer.
- Steam generators.

G. **Pipe Rupture**

Failure scenarios in the different piping systems at the plant that might result in a LOCA or otherwise affect the performance of other systems in their ability to perform a specified safety function must be evaluated to ensure that overall plant safety will not be jeopardized.

Pipe break/crack locations (for the consideration of the design and placement of pipe whip restraints, jet impingement barriers and missile protection) are postulated based on system geometry and pipe stress levels.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 7 of 7)

The following lists hypothetical break locations:

- Terminal ends/anchor points.
- Any intermediate locations between terminal ends where either the sum of primary and secondary circumferential or longitudinal stresses derived on an elastic basis under the loads associated with seismic events and operational plant conditions exceeds 0.8 ($S_h + S_A$), or the secondary circumferential or longitudinal stress exceeds 0.8 S_A.

Two additional intermediate locations are selected based on the points of high stress as identified by UFSAR Chapter 10A. No breaks occur in short pipe runs of 5 pipe diameters or less in length.

A critical crack defined as one-half the pipe diameter in length and one-half the pipe wall thickness in width is postulated to occur at any location. Since a crack is postulated to occur anywhere, select locations having the most adverse effect on plant safety.

Pipe breaks and/or cracks are postulated to occur in piping (greater than 1" nominal size) of high energy systems, which are defined as those fluid systems where either of the following process conditions are maintained during normal plant conditions:

- Maximum operating temperature exceeds 200° F.
- Maximum operating pressure exceeds 275 psig.

Normal plant conditions are defined as normal steady state or hot standby (Modes 1, 2, 3).

Piping systems that contain fluids above atmospheric conditions but below high energy conditions during normal plant conditions are classified as moderate energy. Pipe breaks and/or cracks are not postulated in moderate energy systems at CCNPP.

Additional information may be found in UFSAR Section 10A and Mechanical Design Criteria Appendix A.

Primary Stress Limits for B31.1 Pipe for Design and Level 1 Conditions
(also applicable to B31.7 Class II and Class III)

		DESIGN	LEVEL 1
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING SYSTEM	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	YES
	SSE INERTIA	NO	NO
	SAFETY/RELIEF VALVE DISCHARGE	NO	YES
	FLUID TRANSIENT	NO	YES
	PIPE RUPTURE	NO	NO
HOOP STRESS		$\frac{P(D - 2yt)}{2tE} \le 1.0\ S_h$	$\frac{P(D - 2yt)}{2tE} \le 1.2\ S_h$
LONGITUDINAL STRESS		$\frac{Pd^2}{D^2 - d^2} + \frac{M}{Z} \le 1.0\ S_h$	$\frac{Pd^2}{D^2 - d^2} + \frac{M}{Z} \le 1.2\ S_h$

NOTES:

1. See sheet 7 for calculating moment and application of stress intensification factors.
2. B31.1 Seismic Category II pipe is only analyzed for Design and Level 1 loads, and does not consider earthquake effects.

Primary Stress Limits for B31.1 Pipe for Level 2 and Level 3 Conditions
(also applicable to B31.7 Class II and Class III)

		LEVEL 2	LEVEL 3
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING SYSTEM	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	NO
	SSE INERTIA	YES	YES
	SAFETY/RELIEF VALVE DISCHARGE	YES	YES
	FLUID TRANSIENT	YES	YES
	PIPE RUPTURE	NO	YES
HOOP STRESS		$\frac{P(D - 2yt)}{2tE} \le 1.0\, S_D$	$\frac{P(D - 2yt)}{2tE} \le 1.0\, S_L$
LONG. MEMBRANE STRESS		$\frac{PD}{4t} \le 1.0\, S_D$	$\frac{PD}{4t} \le 1.0\, S_L$
LONG. BENDING STRESS		$\frac{M}{Z} \le \frac{4}{\pi} S_D \cos\left[\frac{\pi}{2S_D}\left(\frac{PD}{4t}\right)\right]$	$\frac{M}{Z} \le \frac{4}{\pi} S_L \cos\left[\frac{\pi}{2S_L}\left(\frac{PD}{4t}\right)\right]$

NOTES:

1. See sheet 7 for calculating moment and application of stress intensification factors.
2. Ignore these load levels for B31.1 Seismic Category II pipe.
3. Bracketed value [ ] is in radians.

B31.1

Secondary Stress Range for B31.1 Pipe for Level 1 Loads Sets (also applicable to B31.7 Class II and Class III)

		LEVEL 1
MOMENT (1)	OBE SAM	YES
	THERMAL EXPANSION	YES
	THERMAL AM	YES
	LONGITUDINAL STRESS RANGE (2)	$\frac{M}{Z} \leq 1.0\ S_A$

NOTES:

1. See sheet 9 for calculating moment and application of stress intensification factors.
2. The term $f(S_h - S_L)$ may be added to S_A, where S_L is the primary longitudinal stress calculated in Table 1 for Level 1 sustained loads (i.e. weight and pressure).
3. B31.1 Seismic Category II pipe does not consider earthquake effects.

Pipe Stress Legend for B31.1 (1967)

P	=	Pressure, psi.
M	=	Resultant moment, lb.-in.
i	=	Stress intensification factor (see page B31.1 Appendix D).
D	=	Outside diameter of pipe, in.
d	=	Inside diameter of pipe, in.
t	=	Wall thickness, in.
y	=	See B31.1 Table 104.1.2 (a) 2.
E	=	Joint efficiency (see B31.1 Table 102.4.3).
Z	=	Section modulus of pipe, in.^{3}
S_h	=	Allowable stress at temperature, psi (B31.1 pipe use B31.1 Appendix A Table A1 and Table A2. B31.7 Class II pipe use B31.7 Appendix A Table A8. B31.7 Class III pipe use B31.7 Appendix A Table A8 and A9).
S_m	=	**Tabulated allowable stress limit at temperature from ASME B&PV Code Section III or ANSI B31.7 (Table A.1).**
S_D	=	**S_y (for ferritic steels) and 1.2 S_m (for austenitic steels) (see UFSAR Table 4-8).**
S_L	=	S_y + 1/3 (S_u - S_y) (see UFSAR Table 4-8).
S_y	=	Yield strength of material at temperature, psi (see ASME (1967)).
S_u	=	Tensile strength of material at temperature, psi (see ASME (1967)).
S_A	=	f(1.25 S_c + 0.25 S_h)
S_c	=	Allowable stress at minimum environmental temperature, psi (B31.1 pipe use B31.1 Appendix A Table A1 and Table A2, B31.7 Class II pipe use B31.7 Appendix A Table A8; B31.7 Class III pipe use B31.7 Appendix A Table A8 and A9)
f	=	Stress range reduction factor (B31.1 Table 102.3.2(c))

B31.1

Primary Stress Limits for ASME Class 2 and Class 3 Pipe for Design and Level 1 Conditions

		DESIGN	LEVEL 1
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	YES
	SSE INERTIA	NO	NO
	SAFETY/RELIEF VALVE DISCHARGE	NO	YES
	FLUID TRANSIENT	NO	YES
	PIPE RUPTURE	NO	NO
HOOP STRESS		$\frac{P(D - 2yt)}{2t} \le 1.0\, S_h$	$\frac{P(D - 2yt)}{2t} \le 1.1\, S_h$
LONGITUDINAL STRESS		$\frac{Pd^2}{D^2 - d^2} + \frac{0.75iM_A}{Z} \le 1.0\, S_h$	$\frac{Pd^2}{D^2 - d^2} + \frac{0.75i(M_A + M_B)}{Z} \le 1.2\, S_h$

NOTES:

1. See sheet 7 for calculating M_A and M_B.

ASME CLASS 2/3

Primary Stress Limits for ASME Class 2 and Class 3 Pipe for Level 2 and Level 3 Conditions

		LEVEL 2	LEVEL 3
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	NO
	SSE INERTIA	YES	YES
	SAFETY/RELIEF VALVE DISCHARGE	YES	YES
	FLUID TRANSIENT	YES	YES
	PIPE RUPTURE	NO	YES
HOOP STRESS		$\frac{P(D - 2yt)}{2t} \leq 1.5\, S_h$	$\frac{P(D - 2yt)}{2t} \leq 1.8\, S_h$
LONGITUDINAL STRESS		$\frac{Pd^2}{D^2 - d^2} + \frac{0.75(M_A + M_B)}{Z} \leq 1.8\, S_h$	$\frac{Pd^2}{D^2 - d^2} + \frac{0.75(M_A + M_B)}{Z} \leq 2.4\, S_h$

NOTES:

1. See sheet 7 for calculating M_A and M_B

Secondary Stress Range for ASME Class 2 and Class 3 Pipe for Level 1 Load Sets and Unrepeated Anchor Movements

		LEVEL 1	Unrepeated AM
MOMENT (1)	OBE SAM	YES	NO
	THERMAL EXPANSION	YES	NO
	THERMAL AM	YES	NO
	UNREPEATED AM	NO	YES
	LONGITUDINAL STRESS RANGE (2)	$\frac{iM_C}{Z} \le 1.0\,S_A$	$\frac{iM_D}{Z} \le 3.0\,S_C$

NOTES:

1. See sheet 8 for calculating M_C and M_D.
2. The term $f(S_h - S_L)$ may be added to S_A, where S_L is the primary longitudinal stress calculated in Table 1 for Level 1 sustained loads (i.e. weight and pressure).

[illegible]

Pipe Stress Legend for ASME Class 2 and Class 3 Systems

P	=	Pressure, psi.
M_A	=	Resultant static moment, lb.-in.
M_B	=	Resultant dynamic moment, lb.-in.
M_C	=	Resultant moment from expansion and anchor movements, lb.-in.
M_D	=	Resultant moment from an unrepeated anchor movement, lb.-in.
i	=	Stress intensification factor (see NC-/ND-3673).
D	=	Outside diameter of pipe, in.
d	=	Inside diameter of pipe, in.
t	=	Wall thickness, in.
y	=	See NC-/ND-3641.1.
Z	=	Section modulus of pipe, in.^{3}
S_h	=	Allowable stress at temperature, psi (NC uses ASME Appendix I Table I-7.0; ND uses ASME Appendix I Table I-7.0 or I-8.0).
S_A	=	$f(1.25\ S_c + 0.25\ S_h)$.
S_c	=	Allowable stress at minimum environmental temperature, psi (NC uses ASME Appendix I Table I-7.0; ND uses ASME Appendix I Table I-7.0 or I-8.0).
f	=	Stress range reduction factor (ASME NC/ND Table 3611.2(e)-1).

ASME CLASS 2/3

2" and Smaller Piping

- WO-30 Cookbook
  - » Factor of safety of 10 on the Code or FS of 40 on failure
  - » Seismic is based on limiting freq. to 20 Hz (i.e., ZPA at CCNPP)
- M-18 Cookbook
  - » Factor of Safety of 6 above the Code or FS of 24 on Failure.
  - » Seismic is based on limiting freq. to corresponding acceleration of 1 g

Analysis Capabilities @ CCNPP

- AutoPipe
- ME101
- ANSYS (under Development)

File & Retrieval Methods

- Nucleis/NORMS
  - » Involved process using word searches and database cross references
- Imaging
  - » Most hard copies have been imaged, which makes reference vary rapid. But, complete retrieval can be time consuming.

Example 1 - Feedwater System

- System Description & Overview
- Load Cases
- Stress Ratio's

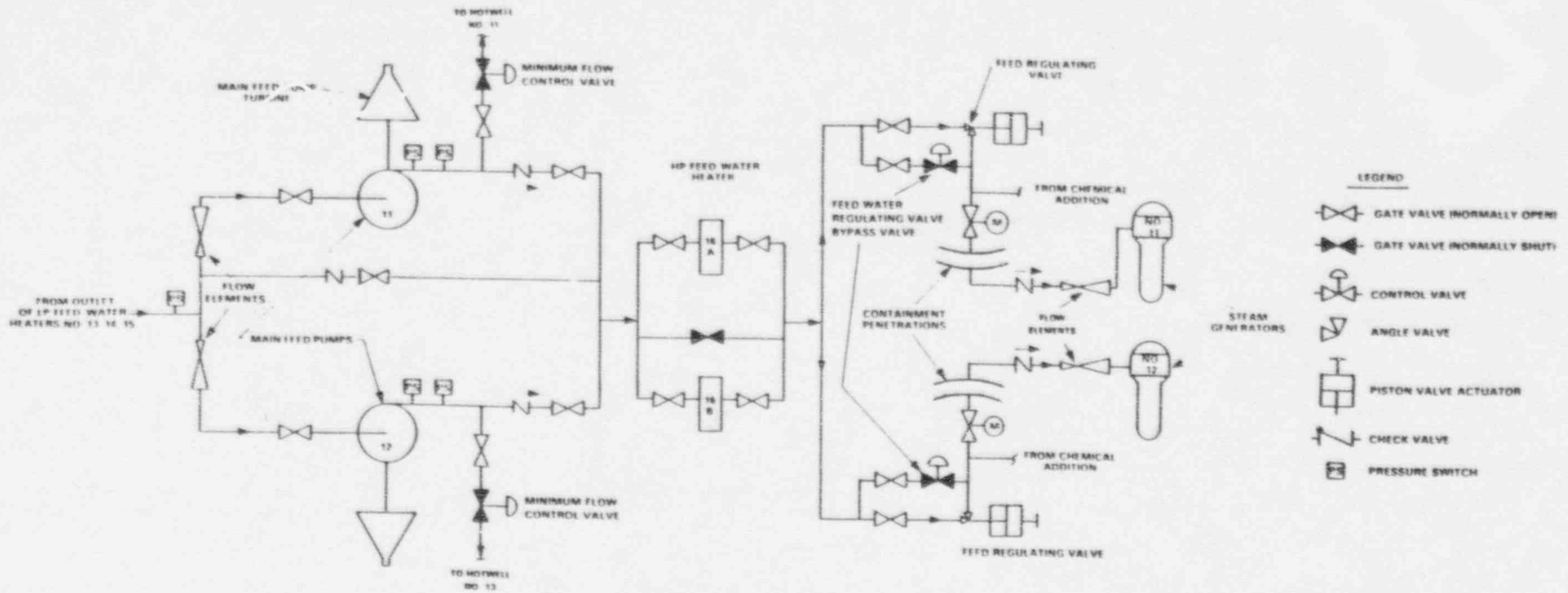


FIGURE 32 - 1

MAIN FEEDWATER SYSTEM SIMPLIFIE
BLOCK DIAGRAM

Example 2 - Saltwater System

- System Description & Overview
- Load Cases
- Stress Ratio's

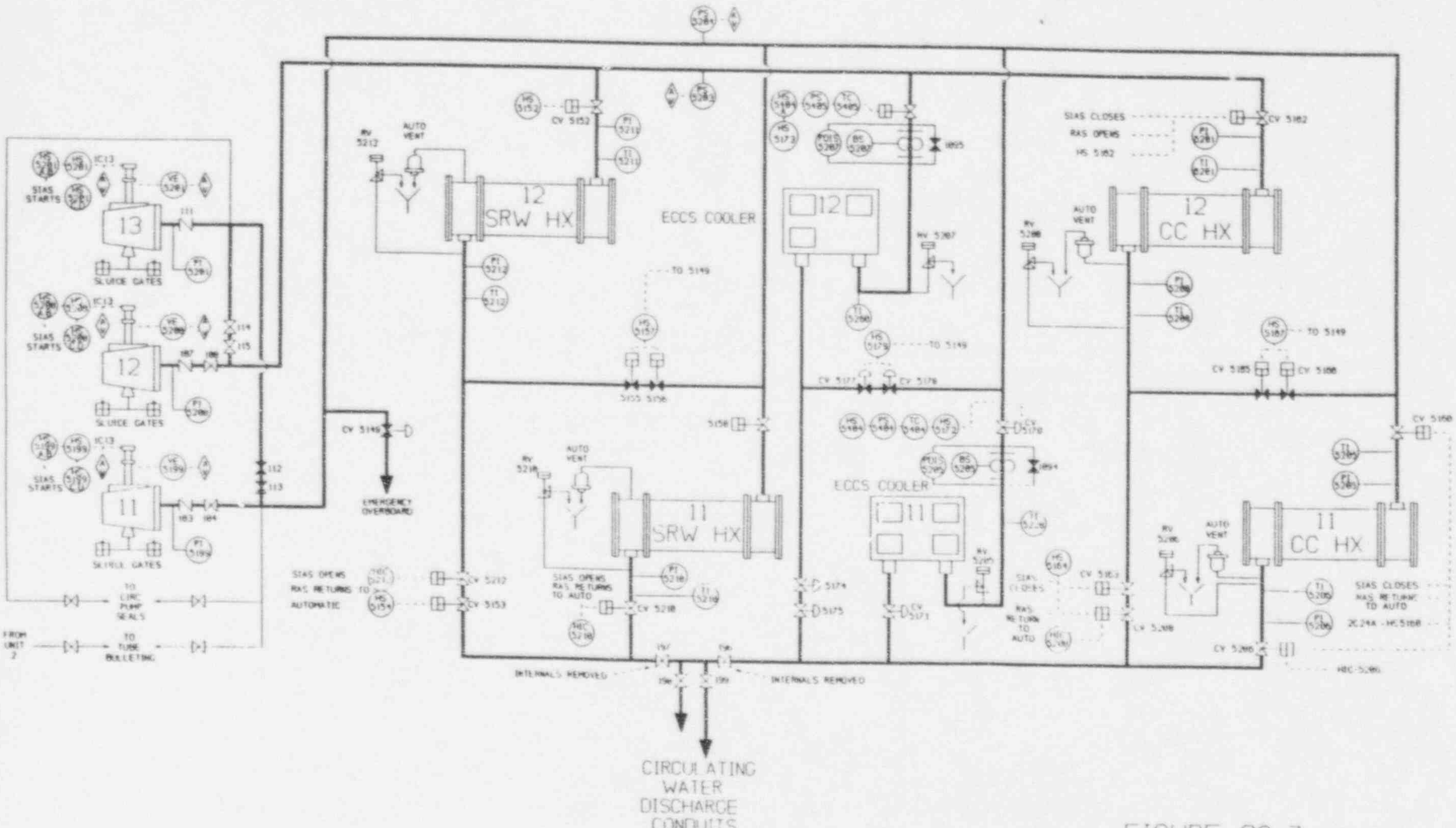


FIGURE 38-7
SALTWATER SYSTEM

CALVERT CLIFFS ENGINEERING STANDARD

Number: ES-040

PIPING DESIGN CRITERIA

Revision 00

Effective: DEC 1 3 1995

USER CONTROLLED

DEC 1 3 95

Writer(s):	J. S. Gray	Date:	11/17/95
Technical Reviewer:	J. A. Crunkleton	Date:	11/17/95
Sponsor:	M. J. Gahan, III	Date:	11.19.95
Approved:	General Supervisor - Design Engineering	Date:	11/20/95

RECORD OF REVISION

Revision	Summary of Change
0	This ES-040 supersedes DS-040. ES199501673 was initiated by the GS-DES to facilitate the transference of this design standard to an engineering standard. This revision is only a editorial/formatting change.

TABLE OF CONTENTS

SECTION TITLE PAGE

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Purpose

This engineering standard provides pipe stress criteria, attached equipment load criteria, component pipe support load criteria, and support and building steel stress criteria applicable to the evaluation of piping systems at the Calvert Cliffs Nuclear Power Plant (CCNPP), Units 1 and 2. Satisfaction of the criteria contained in or referenced by this document during design and modifications qualifies a piping system and/or piping component for licensed service in accordance with the UFSAR **[B-1]**.

It is not the intent of this document to provide detailed techniques or methodologies for the design and analysis of piping systems.

1.2 Scope/Applicability

This engineering standard is applicable for evaluations of existing or modified piping for systems having the following codes of record:

- B31.1 Seismic Category I and Seismic Category II (USAS B31.1).
- B31.7 Class II and Class III (USAS B31.7).
- ASME Class 2 and Class 3 (Section III).
- B31.7 Class I (USAS B31.7).

Refer to Section 5.1 for applicable code editions and addenda.

2.0 REFERENCES

2.1 Developmental References

A. AISC, Manual of Steel Construction, 7th Edition

B. ASME Boiler and Pressure Vessel Code, Section III & XI, 1983 Edition.

C. ASME Boiler and Pressure Vessel Code, Section III, 1977 Edition up to and including Summer 1978 Addenda.

D. ASME Boiler and Pressure Vessel Code, Section III, all Rulings and Addenda up to Winter 1967 with Summer 1969 Addenda and Code Case N-1401 added.

E. ASTM, Annual Book of ASTM Standards, 1985

F. Baltimore Gas and Electric Company, Calvert Cliffs Nuclear Power Plant Units 1 and 2, Updated Final Safety Analysis Report.

2.1 Developmental References (Continued)

G. Baltimore Gas and Electric Company, CCNPP Design Engineering, EN-1-200 (draft), "Preparation and Control of Calvert Cliffs Design Standards"

H. Bechtel Power Corporation, Job No. 11865, "CCNPP Units 1 and 2, Bechtel Project Engineering Plan for NRC I.E. Bulletin 79-14," Rev. 5, October 1982.

I. Bechtel Power Corporation, Job No. 11865, File No. 0151, Rev. 0, "Design Criteria Document for Auxiliary Feedwater Modification, CCNPP FCR 79-1062," October 1981.

J. Letter to BG&E from Hopper and Associates, HABGE-04/94-0252, "Piping Supports Extreme Load Design Limits; March 8, 1994, Technical Interchange Meeting Minutes," April 5, 1994

K. Letter to BGE from Hopper and Associates, HABGE-04/94-0258, "Calvert Cliffs Design Standard Number: DS-040 Piping Design Criteria Revision 0," April 26, 1994.

L. "Selected Papers by Nathan M. Newmark," Civil Engineering Classics, ASCE, NY, NY, 1976

M. SQUG, "Generic Implementation Procedure for Seismic Verification of Nuclear Plant Equipment," Rev. 2, February 1992

N. US AEC, Regulatory Guide 1.48, "Design Limits and Loading Combinations for Seismic Category I Fluid System Components," May 1973.

O. US AEC, Regulatory Guide 1.92, Rev. 1, "Combining Modal Response and Spatial Components in Seismic Response Analysis," February 1976.

P. US NRC, IE Bulletin 79-02, "Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts," March 1979.

Q. US NRC, Regulatory Guide 1.29, "Seismic Design Classification," September 1978

R. USAS B31.1 Power Piping Code, 1967 Edition with B31.1b-1971, B31.1c-1972, and B31.1d-1972 Addenda.

S. USAS B31.7 Nuclear Power Piping Code, 1969 Edition with B31.7b-1971 and B31.7c-1971 Addenda and Code Cases 83 and 1477.

2.2 Performance References

A. AISC, Manual of Steel Construction, 6th Edition.

B. AISC, Manual of Steel Construction, 7th Edition.

C. ASME Boiler and Pressure Vessel Code, Code Case N-411, February 1986.

D. ASME Boiler and Pressure Vessel Code, Section III, 1977 Edition up to and including Summer 1978 Addenda.

E. ASME Boiler and Pressure Vessel Code, Section III, all Rulings and Addenda up to Winter 1967 with Summer 1969 Addenda and Code Case N-1401 added.

F. ASME Boiler and Pressure Vessel Code, Section XI, 1983 Edition.

G. Baltimore Gas and Electric Company, Calvert Cliffs Nuclear Power Plant Units 1 and 2, Updated Final Safety Analysis Report.

H. Bechtel Power Corporation, Design Guide No. C-2.40, Rev. 1, "Concrete Expansion Anchors," February 1984.

I. Bechtel Power Corporation, Job No. 11865, Drawing No. M-601 B, Rev. 15, "Piping Class Summary Analysis Requirements," November 1992.

J. Bechtel Power Corporation, Job No. 11865, Drawing No. M-601, Rev. 27, "Piping Class Summary Sheets," April 1991.

K. Bechtel Power Corporation, Job No. 11865, TRD-M-1046, Rev. 2, "Piping and Pipe Support Installation Performance Standard," October 1982.

L. Bechtel Power Corporation, Job. No. 11865, Drawing No. M-600, Rev. 43, "Piping Class Sheets," July 1989.

M. BGE, Drawing No. 60-064-E, Sheets 5 & 6.

N. ES-022, Calculations

O. ITT Grinnell LCD-105.

P. ITT Grinnell PH-74-R Catalog.

Q. USAS B31.1 Power Piping Code, 1967 Edition with B31.1b-1971, B31.1c-1972, and B31.1d-1972 Addenda.

R. USAS B31.7 Nuclear Power Piping Code, 1969 Edition with B31.7b-1971 and B31.7c-1971 Addenda and Code Cases 83 and 1477.

3.0 DEFINITIONS

A. **Design-Basis Events**

Conditions of operation including anticipated operational occurrences, analyzed accidents, external events or natural phenomena for which SSCs are designed to ensure those SSCs are capable of performing their specified functions.

B. **Loss-Of-Coolant Accident (LOCA)**

Those accidents that result from the loss of reactor coolant, at a rate in excess of the reactor coolant makeup system, from breaks in the reactor coolant pressure boundary, up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.

C. **Operating-Basis Earthquake (OBE)**

The largest earthquake postulated to occur in the vicinity of the plant during the plant's lifetime. Also referred to as the "design earthquake."

D. **Safety Analysis Report (SAR)**

The SAR is that set of criteria, standards, and commitments to the NRC to which every system, structure, and component in the plant must adhere to in order to qualify for licensed service. Also referred to as the "current licensing basis."

E. **Safe Shutdown Earthquake (SSE)**

The maximum hypothetical earthquake postulated to occur in the vicinity of the plant. Also referred to as the "design-basis earthquake" or "DBE."

F. **Seismic Anchor Movement (SAM)**

The displacement of anchor points to which a piping system is attached. Examples would be buildings and large equipment to which piping is connected, moving during a seismic event.

G. **Seismic Category I**

Those systems which must be designed to withstand both operating-basis earthquake (OBE) and safe shutdown earthquake (SSE) loads. These are systems whose failure could cause uncontrolled release of radioactivity or those essential for immediate and long-term operation following a loss-of-coolant accident (LOCA). Also referred to as "Class 1 (Seismic)" as defined in UFSAR Section 5A.3.1.2, or "Seismic."

3.0 DEFINITIONS (Continued)

H. **Seismic Category II**

Those systems not essential to safe shutdown of the plant, and those whose failure would not result in the uncontrolled release of radioactivity. Also referred to as "Class 2 (Seismic)," as defined in UFSAR Section 5A.3.1.3, or "Non-Seismic."

I. **Square-Root-Sum-of-the-Squares (SRSS)**

A method of combining the responses of cyclic dynamic loads which reflects the fact that the peak response of each cyclic load does not necessarily happen in phase with the peaks from other cyclic loads. This approach is used to combine the separate modal responses when performing a response spectrum analysis; it is also used to combine the overall responses of different cyclic dynamic loads. See Attachment 3 for examples.

J. **Thermal Anchor Movement (TAM)**

The thermally induced displacements of anchor points to which a piping system is attached. Examples would be the displacement of a heat exchanger nozzle caused by expansion of the exchanger, or displacement of a containment penetration anchor caused by expansion of the containment during a LOCA.

K. **Updated Final Safety Analysis Report (UFSAR)**

This document contains design-basis information for all systems at CCNPP.

4.0 RESPONSIBILITIES

4.1 Principal Engineers

Principal Engineers are responsible for assigning engineering personnel who are qualified to perform design and analyses of piping and/or pipe supports.

4.2 Originator and Reviewer

In most cases piping and/or pipe support analyses will be governed by the procedural requirements in ES-022, Calculations. When applicable, the Originator and Reviewer are responsible for comply with ES-022, Calculations requirements and for clearly documenting the reasons and rationale for using criteria which differ from those identified in this engineering standard.

NOTE

This engineering standard restates and attempts to clarify licensing basis information. It may be necessary to seek NRC concurrence of piping criteria different than that contained in this engineering standard. Evaluate any alternate piping criteria to see if it represents an "Unreviewed Safety Question" (USQ).

5.0 STANDARD/METHOD

5.1 Codes and Standards

The following codes and standards govern the design and evaluation of piping covered by this document for CCNPP Units 1 and 2:

- USAS B31.7 Nuclear Power Piping Code, 1969 Edition with B31.7b-1971 and B31.7c-1971 Addenda
- USAS B31.1 Power Piping Code, 1967 Edition with B31.1b-1971, B31.1c-1972, and B31.1d-1972 Addenda
- AISC Manual of Steel Construction, 7th Edition (for non-catalog steel pipe supports on B31.7 and B31.1 systems)
- CCNPP UFSAR (Section 5A3.1.5 and Table 4-8 list allowable stresses and/or other limits for use with the above Codes when evaluating B31.1 and B31.7 piping systems for SSE and SSE + pipe rupture conditions. A discussion of this basis is contained in Attachment 1)
- ASME Boiler and Pressure Vessel Code, Section III, 1977 Edition through Summer 1978 Addenda (for pipe and pipe supports of motor-driven train of AFW)

5.2 Pipe Stress Criteria

The stress criteria to be satisfied by pipe within the scope of this document are listed by section according to the Code which governed the original design:

- B31.1 Seismic Category I and II (USAS B31.1); also applicable to B31.7 Class II and Class III (USAS B31.7)
- ASME (1977) Class 2 and Class 3 (Section III)
- B31.7 Class I (USAS B31.7)

The service levels the pipe must withstand and the associated stress criteria are presented in tabular format within the attachments referenced by each section.

The service levels and associated loads are described in Attachment 2, Service Levels and Load Types. When considering the load combinations at the different service levels, use the most severe, yet realistic, combination of associated loads. Since excessive conservatism can be costly, avoid the temptation to combine loads which do not occur at the same time (unless required to do so by licensing or design commitments).

5.2 Pipe Stress Criteria (Continued)

B31.1 (1967) and B31.7 did not provide allowable stresses for use with extreme loads (SSE, pipe rupture). The criteria used by systems whose construction was governed by these Codes in meeting these loads were developed based on the knowledge and experience of the nuclear industry at the time. These criteria are contained in the UFSAR; refer to Attachment 1, Licensing and Design Basis Meeting revised, for further discussion.

A. USAS B31.1 Requirements (Applicable to USAS B31.7 Class II and Class III):

USAS B31.1 Code requirements, including those applicable to the evaluation of USAS B31.7 Class II and Class III systems, limit the following:

- Primary stress, to prevent bursting or rupture.
- Secondary stress, to prevent incremental plastic collapse.

The evaluation criteria in this section follows the approach outlined in B31.1 (1967) Sections 102 and 104.

No explicit evaluation is required for high-cycle fatigue; however, if high-cycle fatigue is anticipated to be a problem, perform an evaluation according to an established methodology (the method used for B31.7 Class I pipe in 5.2.C is acceptable).

Evaluate flanges, expansion joints and brittle/non-ductile connections for displacement-controlled loads at all service levels. Use the load combinations in Attachment 3, B31.1 Pipe Stress and Support Capacity Tables, Table 4, with pressure loadings when analyzing these items. Manufacturer's allowables are not to be exceeded without performing a detailed component analysis.

1. Primary Stress

For Seismic Category I B31.1 pipe, limits on primary stresses must satisfy all service level limits, i.e., Design, Level 1, Level 2, and Level 3, as shown in Attachment 3, Tables 1 and 2. The stress limits for the first two service levels are taken from B31.1 (1967) Sections 102.3.2(d) and 102.2.4(1); stress limits for the second two service levels are taken from UFSAR Table 4-8 load levels 2 and 3. Seismic Category II B31.1 pipe is only required to satisfy limits on primary stress for Design and Level 1 load combinations (excluding OBE effects).

Longitudinal stresses are checked using the criteria in B31.1 Section 102.3.2(d) for Design and Level 1 load combinations. Use the limit equations from UFSAR Table 4-8 (with P_m = PD/4t and P_B = M/Z) when evaluating the pipe under Level 2 and Level 3 load combinations. The pressure design equation from B31.1 Section 104.1.2(a) has been rearranged for the purpose of checking hoop stress from both pressure and local forces for all service levels.

5.2 Pipe Stress Criteria (Continued)

2. Secondary Stress

For both Seismic Category I and Seismic Category II B31.1 pipe, evaluate the maximum longitudinal secondary stress range for Level 1 load sets as shown in Attachment 3, Table 3. The criteria used is from B31.1 Section 102.3.2(c). A load set is defined as those values of moment from both SAM and thermal activity which are applied simultaneously. The stress range is the difference in stress between the two sets. The unloaded condition of zero moment (except piping system deadweight) is considered as one of the load sets. Exclude OBE SAM effects when evaluating secondary stresses in Seismic Category II B31.1 pipe.

B. ASME BPV Code Class 2 and Class 3 Requirements:

ASME BPV Code Class 2 and Class 3 design criteria as stated in Section III Subsections NC (Class 2) and ND (Class 3) limit the following:

- Primary stress, to prevent bursting or rupture.
- Secondary stress, to prevent incremental plastic collapse.

The evaluation criteria in this section follows the approaches outlined in ASME Section III NC-/ND-3600.

No explicit evaluation is required for high-cycle fatigue; however, if high-cycle fatigue is anticipated to be a problem, consider performing an evaluation according to an established methodology (the criteria used for B31.7 Class I pipe in Section 5.2.C of this document is acceptable, as are criteria for ASME Class 1 pipe).

Evaluate flanges, expansion joints and brittle/non-ductile connections for displacement-controlled loads at all service levels. Use the load combinations in Attachment 4, ASME Class 2 and Class 3 Pipe Stress and Support Capacity Tables, Table 4, with pressure loadings when analyzing these items. Ensure manufacturer's allowables are not exceeded without performing a detailed component analysis.

1. Primary Stress

Primary stresses must satisfy all service level limits, i.e., Design, Level 1, Level 2, and Level 3, as shown in Attachment 4, Tables 1 and 2. The limits for these service levels are taken from Section III NC-/ND-3611.2 according to the recommendations of AEC Reg. Guide 1.48, which is cited by "AFW Design Criteria" (Bechtel) as providing information on load combinations and allowable stresses for the motor-driven AFW system. This regulatory position states that for ASME Class 2 and Class 3 pipe, the upset/Level B allowable will be used for meeting normal and occasional loads acting with the OBE, and the emergency/Level C allowable will be used for meeting normal, occasional, and faulted loads acting with the SSE.

5.2 Pipe Stress Criteria (Continued)

Longitudinal stresses are checked using the procedures in NC-/ND-3650. NC-/ND-3652.1 Equation (8) is used for checking the Design Level; NC-/ND-3652.2 Equation (9) is used for checking Levels 1-3. The working pressure equation from NC-/ND-3640 has been rearranged for the purpose of checking hoop stress from both pressure and local forces, e.g., welded attachments, for all service levels.

2. Secondary Stress

Evaluate the maximum longitudinal secondary stress range for Level 1 load sets as shown in Attachment 4, Table 3. The equation used is NC-/ND-3652.3(a) Equation (10). A load set is defined as those values of moment from SAM and thermal activity which are applied simultaneously. The stress range is the difference in stress between the two sets. The unloaded condition of zero moment (except piping system deadweight) is considered as one of the load sets.

Evaluate the maximum longitudinal secondary stress range for any unrepeated anchor movements as shown in Attachment 4, Table 3, such as those resulting from building settlement or from containment expansion during a LOCA. The equation used is NC-/ND-3652.3(b) Equation (10a).

C. USAS B31.7 Class I Requirements

USAS B31.7 Class I requirements limit the following:

- Primary stress intensity, to prevent bursting or rupture.
- Primary plus secondary stress intensity range, to prevent incremental plastic collapse.
- Peak stress intensity range cumulative usage, to protect against high-cycle fatigue.

The criteria in this section, uses the simplified approach described in B31.7 Sections 1-704 and 1-705. If a more rigorous analysis is desired, use the alternative rules of B31.7 Appendix F.

Evaluate flanges, expansion joints and brittle/non-ductile connections for displacement-controlled loads at all service levels. Use the load combinations in Attachment 5, B31.7 Class 1 Pipe Stress and Support Capacity Tables, Table 4, with pressure loadings when analyzing these items. Ensure manufacturer's allowables are not exceeded without performing a detailed component analysis.

5.2 Pipe Stress Criteria (Continued)

1. Primary Stress Intensity

Primary stress intensities must satisfy all service level limits, i.e., Design + Level 1, Level 2, and Level 3, as shown in Attachment 5, Tables 1 and 2. The stress intensity limits and load combinations for the different service levels are taken from UFSAR Table 4-8.

The limit equations from UFSAR Table 4-8 governing bending and membrane stress have been expressed in terms of "B" stress indices as used in B31.7 Section 1-705.1 for checking longitudinal stresses.

The pressure design equation from B31.7 Section 1-704.1 has been rearranged for the purpose of calculating hoop stress from both pressure and local forces, e.g., welded attachments.

2. Primary Plus Secondary Stress Intensity Range

Evaluate the longitudinal primary plus secondary stress intensity range for Level 1 load sets as shown in Attachment 5, Table 3. A load set is defined as those values of pressure, moment, and thermal gradients which are applied simultaneously. The stress range is the difference in stress between two load sets. The unloaded condition of zero pressure, zero moment (except pipe weight) and zero thermal gradient is considered as one of the load sets. The equation used for this evaluation is B31.7 Section 1-705.2 Equation (10). If this relationship cannot be satisfied for all stress ranges associated with Level 1, use the simplified elastic-plastic discontinuity analysis of B31.7 Section 1-705.4.

3. Peak Stress Intensity Range Cumulative Usage

Determine the longitudinal peak stress intensity range cumulative usage for Level 1 load sets as shown in Attachment 5, Table 3. For each load set, calculate the peak stress intensity range. The equation used is B31.7 Section 1-705.3 Equation (11).

Evaluate cumulative usage as follows:

a. Designate the specified number of times each type of stress cycle of types 1, 2, 3, etc., will be repeated during the life of the system or part thereof as n_i, where i=1, 2, 3... respectively. In determining n_i, consider the superposition of cycles of various origins that produce a total stress range greater than the stress range of the individual cycles.

b. For each type of stress cycle, determine the alternating stress intensity S_{Ai} as shown in Attachment 5, Table 3.

5.2 Pipe Stress Criteria (Continued)

c. For each value of S_{Ai}, use the fatigue curves in B31.7 Section 1-705.3 Figures 1-705.3.3(a) and 1-705.3.3(b) to determine the maximum number of repetitions that could be allowed if this cycle were the only one acting. Call these values N_i.

d. For each stress cycle, determine the cumulative usage according to:

$$u_i = \frac{n_i}{N_i}$$

e. Calculate the cumulative usage factor U where:

$$U = \Sigma u_1$$

f. U must be ≤ 1.0

5.3 Pipe Support Capacities and Allowables

Pipe supports can be categorized as either "component standard supports" or "support steel." "Component standard supports" are those available for purchase from a vendor's catalog (such as struts, clamps, rods, springs, and snubbers). "Support steel" comprises that group of supports that is made by welded or bolted structural steel members to form a pipe support. "Support Steel" can also connect "component standard supports" to structural steel.

The criteria, which all pipe supports for piping systems covered by this engineering standard must satisfy, are listed by section according to the Code which governed the design of the piping system:

- B31.1 Seismic Category I and II (USAS B31.1), also applicable to B31.7 Class II and Class III (USAS B31.7).
- ASME Class 2 and Class 3 (ASME, Section III).
- B31.7 Class I (USAS B31.7).

The service levels that the pipe supports must withstand and the associated design criteria are presented in tabular format within Attachments referenced by each section. These service levels are described in Attachment 2.

Service levels and design criteria have also been provided for concrete expansion anchors and anchor studs, which often serve as a link between the pipe support and the concrete portions of the building, and for building steel to aid in the analysis of those portions of the building structure to which pipe supports are attached. These criteria are contained in subsections to this engineering standard, titled as follows:

5.3 Pipe Support Capacities and Allowables (Continued)

- Concrete Expansion Anchors and Imbedded Studs.
- Building Steel.

When considering the load combinations at the different service levels, use the most severe yet realistic combination of service levels and associated loads. Loads which do not normally occur at the same time should not be added together for conservatism. Since excessive conservatism can be costly, avoid the temptation to combine loads which do not occur at the same time (unless required to do so by licensing or design commitments).

AISC 7th Edition (which applies to steel pipe supports on B31.1 and B31.7 systems) did not provide allowable stresses for use with extreme loads (SSE, pipe rupture). The design criteria used by systems whose construction was governed by this Code in meeting these loads were developed based on the knowledge and experience of the nuclear industry at the time. These criteria are contained in the UFSAR; refer to Attachment 1, for further discussion.

A. Pipe Supports of B31.1 Systems (Also Applicable to Supports of B31.7 Class II and Class III Systems)

Pipe supports of Seismic Category I B31.1, B31.7 Class II and B31.7 Class III systems must perform their required functions for four levels of service: Design, Level 1, Level 2, and Level 3. Pipe supports on Seismic Category II B31.1 systems are only analyzed for Design and Level 1 load combinations, excluding OBE effects. Refer to Attachment 3, Tables 4.

1. Component Standard Supports

The original component standard supports of B31.1, B31.7 Class II, and B31.7 Class III piping systems use the allowables listed in the ITT Grinnell PH-74-R Catalog with the following adjustments in capacity for the different service levels:

Level 1:	1.2 x catalog load capacity
Level 2, Level 3:	2.0 x catalog load capacity

These increases in capacity have been documented for use in "Plan for IE 79-14" (Bechtel).

The following exceptions apply:

- Rigid struts: Use the 20% increase in catalog capacity when meeting Level 1 loads; use the Level D allowable from ITT Grinnell LCD-105 when meeting Level 2 and Level 3 loads.

5.3 Pipe Support Capacities and Allowables (Continued)

- Snubbers (Grinnell on Seismic Category I systems; Lisega and Grinnell on Seismic Category II systems): Use the catalog capacity when meeting Design and Level 1 loads; use the "one-time allowable load" listed in the catalog when meeting Level 2 and Level 3 loads.

- Spring hangers: Meet the catalog capacity for all service levels and remain within the spring travel working range.

When new component standard supports are purchased from catalogs that include ASME load ratings, use the following catalog design limits to satisfy the service levels:

Design:	Catalog Level A
Level 1:	Catalog Level B
Level 2, Level 3:	Catalog Level D

Use of these capacities for new supports provides consistency with those capacities used for the original supports to meet the different service levels.

2. Support Steel (Steel Supports)

For the original steel supports of B31.1, B31.7 Class II, and B31.7 Class III systems, use the criteria in the AISC Manual of Steel Construction, 7th Edition, (documented by Bechtel "Plan for IE 79-14") with several enhancements:

Design:	AISC 7th
Level 1:	1.2 x AISC 7th
Level 2:	within yield, 1.5 x AISC 7th
Level 3:	deflection of supports limited to maintain supported equipment within acceptable limits (F_u on elastically calculated stresses).

Where: F_u is the material ultimate stress.

The 20% increase in meeting Level 1 loads is allowed by B31.1 (1967) Section 121.1.2 (1). The limits for response to Level 2 and Level 3 loads are taken from UFSAR Table 4-8.

5.3 Pipe Support Capacities and Allowables (Continued)

The limit of yield may be taken as 1.5 x AISC 7th allowables, with the following exceptions:

- Stresses may not exceed 0.7 F_u
- Shear stress may not exceed 0.42 F_u
- Buckling load may not exceed 2/3 P_{cr}

These adjustments for using F_y as a limit are identical to those required by ASME Section III NF (post 1980) when analyzing linear-type supports under Level C loads (which applies a 1.5 increase to working stress limits), and are therefore deemed acceptable.

To bound reasonable deflection limits for steel supports when analyzing the system under Level 3 loads, use a numerical stress limit of F_u based on elastically calculated stresses. The restrictions for using this limit are contained within Attachment 6, Level 3 Stress Limits for Steel Pipe Supports on Seismic Category I B31.1 and B 31.7 Systems.

B. Pipe Supports of ASME Class 2 and Class 3 Systems

Pipe supports of ASME Class 2 and Class 3 (ASME B&PVC, Section III) systems must perform their required functions for four levels of service: Design, Level 1, Level 2, and Level 3. Allowable limits for meeting the separate service levels have been set in accordance with AEC Reg. Guide 1.48, which is cited by "AFW Design Criteria" (Bechtel) as providing limits and load combinations for the motor-driven AFW system. ASME Level B limits are used for meeting normal and occasional loads acting with the OBE, and ASME Level D limits are used for meeting normal, occasional, and faulted loads acting with the SSE. Refer to Attachment 4, Table 4.

1. Component Standard Supports

Component standard supports of ASME Class 2 and Class 3 piping systems use the indicated catalog allowables at the following service levels:

Design:	catalog Level A
Level 1:	catalog Level B
Level 2, Level 3:	catalog Level D

2. Support Steel (Steel Supports)

The steel supports of ASME Class 2 and Class 3 systems use the criteria of ASME Section III NF-3300 (Class 2) and NF-3400 (Class 3):

Design:	Level A limits
Level 1:	Level B limits
Level 2, Level 3:	Level D limits

5.3 Pipe Support Capacities and Allowables (Continued)

C. Pipe Supports of B31.7 Class I Systems

Pipe supports of B31.7 Class I systems must perform their required functions for four levels of service: Design, Level 1, Level 2, and Level 3.

1. Component Standard Supports

Due to the lack of CCNPP documentation concerning B31.7 Class I piping system component standard support allowables, it is recommended the analyst review the original calculation for these systems before proceeding with an analysis. The following values from the ITT Grinnell PH-74-R Catalog with the following adjustments in capacity for the different service levels may be used as part of a cursory evaluation:

Design + Level 1: catalog load capacity

Level 2, Level 3: 2.0 x catalog load capacity

The unmodified catalog load capacity is used in meeting Design and Level 1 loads to provide consistency with UFSAR Table 4-8, which indicates that no increases in support stress allowables are taken for these combinations. The increased capacities for meeting Level 2 and Level 3 loads have been documented for use by "Plan for IE 79-14" (Bechtel) on Seismic Category I B31.1 systems.

The following exceptions apply:

Rigid struts: use the Level D allowable from ITT Grinnell LCD-105 when meeting Level 2 and Level 3 loads.

Snubbers: use the catalog capacity when meeting Design and Level 1 loads; use the "one-time allowable load" listed in the catalog when meeting Level 2 and Level 3 loads.

Spring hangers: meet the catalog capacity for all service levels and remain within the spring travel working range.

When new components are purchased from catalogs with ASME load ratings, use the following catalog ratings to meet the different service levels:

Design & Level 1: Catalog Level A and B

Level 2, Level 3: Catalog Level D

Use of these capacities for new supports provides consistency with those capacities used for the original supports to meet the different service levels.

5.3 Pipe Support Capacities and Allowables (Continued)

2. Support Steel (Steel Supports)

For the original steel supports of B31.7 Class I systems, use the criteria of the AISC Manual of Steel Construction, 7th Edition (as indicated by Bechtel "Plan for IE 79-14") with several enhancements:

Design + Level 1: AISC 7th

Level 2: within yield, AISC 7th x 1.5

Level 3: deflection of supports limited to maintain supported equipment within acceptable limits (F_u on elastically calculated stresses).

Where: F_u is the material ultimate stress

All limits are taken from UFSAR Table 4-8.

The limit of yield may be taken as 1.5 x AISC 7th allowables, with the following exceptions:

- Stresses may not exceed 0.7 F_u
- Shear stress may not exceed 0.42 F_u
- Buckling load may not exceed 2/3 P_{cr}

These adjustments for using F_y as a limit are identical to those required by ASME Section III NF (post 1980) when analyzing linear-type supports under Level C loads (which applies a 1.5 increase to working stress limits), and are therefore deemed acceptable.

To bound reasonable deflection limits for steel supports when analyzing the system under Level 3 loads, use a numerical stress limit of F_u based on elastically calculated stresses. The restrictions for using this limit are contained within Attachment 6.

D. Concrete Expansion Anchors and Imbedded Studs

Concrete expansion anchors and imbedded studs have been used to attach pipe supports and other equipment to concrete portions of the building structure. The following types have been used on all piping systems covered by this document:

5.3 Pipe Support Capacities and Allowables (Continued)

1. Expansion Anchors

There are two types of expansion anchors: non-ductile and ductile. Non-ductile expansion anchors fail in a non-ductile mode, i.e. by pulling out of the concrete. Ductile expansion anchors fail in a ductile mode, i.e. by yielding of the bolt material. Use the following safety factors (required by NRC IE 79-02) against ultimate capacity for both types of anchors. To meet all service levels specified for the supported piping, capacities may be obtained either from tests, the vendor catalog, or C-2.40 (Bechtel).

a. Non-ductile Expansion Anchors:

(1) Wedge Type (SF=4):

Philips Red Head Wedge Anchor

Hilti Kwik-Bolt Wedge Anchor

Hilti Kwik II Wedge Anchor

Ramset Trubolt Wedge Anchor

(2) Sleeve Type (SF=4):

Liebig Safety Bolt Anchor

(3) Shell Type (SF=5):

Hilti HDI Flush Shell Anchor

b. Ductile Expansion Anchors (SF=4):

Drillco Maxi-Bolts

2. Imbedded Studs

Studs which have been cast in place or grouted in place, and are assured of failing in a ductile mode, i.e. by yielding of the stud material, should use the support steel criteria appropriate to the piping system being analyzed.

5.3 Pipe Support Capacities and Allowables (Continued)

E. Building Steel

Building steel to which pipe supports have been attached should meet the criteria of the AISC 6th edition as indicated by UFSAR Section 5A3.1.8, with the following exceptions specified in that section:

Design:	AISC 6th
Level 1:	0.7 yield
Level 2:	0.9 yield
Level 3:	0.9 yield

Stresses induced in the steel by the supported piping must be combined with all other stresses induced in the member.

5.4 Nozzles

The piping reactions at equipment nozzles must meet the manufacturer's allowables for all service levels. Evaluate the nozzles for displacement-controlled loads using the loads and load combinations listed for pipe supports. Select the applicable pipe support table based on the construction code for the piping being analyzed (pressure loadings must be added to these). In the absence of manufacturer's allowables, the piping reactions should be compared to loads previously approved by the vendor, i.e. loads from a previous analysis. If vendor's allowables cannot be met, but vendor calculations are available, review the calculations for possible errors in classification of the different stress components, e.g., load combinations for different service levels. Correct classification of stresses may demonstrate the capacity to be higher than originally calculated. NB-3000 of ASME Section III (1977) may prove helpful in this regard.

If none of the above options is viable, evaluate the nozzle rigorously by finite-element or other means in order to determine its actual capacity or to verify that the imposed loads result in acceptable stress levels for applicable codes and standards. Use the results of any rigorous evaluation as input for future nozzle validations.

5.5 Pumps and Valves

Evaluate both pumps and valves which are independently attached to structures for loads and service levels listed for pipe supports, based on the attached piping system code (consider as non-ductile).

Check pumps which have restrained motors (independently supported) to ensure the deflection between the pump and the motor will not damage or impede its function for all service levels for which the pump has a safety function.

5.5 Pumps and Valves (Continued)

Similarly, check valves with their operators independently restrained to ensure the deflection between the valve and the operator will not damage or impede its function for all service levels for which the valve has a safety function.

Compare valve accelerations from the piping analysis (OBE, SSE) to the applicable Seismic Qualification Report (SQR) to ensure that acceleration limits are satisfied. If vendor limits do not exist, test data on valves of the same type can be used to establish acceptable limits.

6.0 BASES

[B-1] Baltimore Gas and Electric Company, Calvert Cliffs Nuclear Power Plant Units 1 and 2, Updated Final Safety Analysis Report.

ATTACHMENT 1, LICENSING AND DESIGN BASES MEETING RESULTS
(Page 1 of 4)

INTRODUCTION

This attachment contains a summary of a meeting by members of various CCNPP Engineering Units and several supporting A&E's called to address the situation of when the original design Codes used in the construction of a system give little or no guidance on how to proceed with the evaluation of extreme load conditions. The main focus of the meeting was justifying a proposed stress limit for steel pipe supports within the context of the SAR (this is discussed in Attachment 6, Level 3 Stress Limits for Steel Pipe Supports on Seismic Category I B31.1 and B31.7 Systems. Within the meeting, the relationship between the design Codes and the CCNPP UFSAR was made clear: the UFSAR augmented the design criteria in the Codes, and documented limits for the evaluation of extreme load conditions for equipment and supports.

MEETING SUMMARY

Date March 8, 1994

The meeting was called to address the generic issue of what to do when design Codes give little or no guidance on how to proceed with the evaluation of extreme load conditions on piping system supports.

A presentation was given to propose the use of a 0.4% strain limit as acceptance criteria for steel supports when analyzing for the most extreme or "faulted" condition. The faulted condition is described in ASME Section III as a service level in which gross general deformations with some loss of dimensional stability and damage requiring repair may be tolerated, so long as the component in question performs its intended function. For a piping system, its function is protection of the pressure boundary and delivery of required flow. This service level may be associated with loads from an SSE and LOCA.

Support load types have been categorized as follows:

- Constant force (such as weight).
- Imposed displacement (such as those resulting from the thermal expansion of support equipment).
- Impulsive/impactive/dynamic (such as seismic or transient type loads).

ATTACHMENT 1, LICENSING AND DESIGN BASES MEETING RESULTS
(Page 2 of 4)

The mechanism by which each type of load acts was discussed.

It was shown by energy balance that allowing a linear elastic analyzed stress in a support equal to F_u (Ultimate Stress) for ductile materials would result in an actual strain of no more than 0.4%. This strain limit provides a "safety factor" of at least 5 against the onset of the strain-hardening regime for typical ductile materials, which occurs at 2.0% strain. It was assumed all constant force-type loads would remain below yield, having been limited by previous service levels, and the associated plastic deformation would come from imposed displacements and minor distortion from ductile action of the material under dynamic loads.

These limits are to apply when performing re-evaluations of existing supports. The strain-limit argument was judged acceptable from a physical standpoint. Concerns were raised about low cycle fatigue on supports, ensuring supports have adequate ductility, and consideration of the effect of support ductility on the supported piping. It was remarked low cycle fatigue was not expected to be a problem in light of the low number of cycles a support system was expected to experience during a faulted event. Buckling and brittle fracture were raised as concerns; anchor bolts and structural bolting were also raised as issues in need of resolution.

The list of concerns about using F_u as a limit was formalized as follows:

- Buckling.
- Effect of support displacement on piping stresses.
- Fracture protection verification.

Also, it was suggested a higher strain limit (5%) is acceptable if a detailed inelastic analysis were performed. When using this limit, rules for strain hardening and flow rules would have to be clearly defined.

Anchor bolts were discussed; anchor bolts at the plant have used a safety factor of 4 (5 for shell type). Anchor studs which are cast in place or attached to embed plates should use the same criteria as support steel. It was decided to address the issue of anchor bolt safety factors at a later date, if necessary.

ATTACHMENT 1, LICENSING AND DESIGN BASES MEETING RESULTS
(Page 3 of 4)

The issue of welding was discussed. It was suggested that there should be verification of no fast fracture potential and some field verification of weld quality. It was agreed that welds should be judged by criteria compatible with the steel criteria, i.e,. the welds must not be the weak link in the system. Fast fracture must be addressed; the bottom line is that fracture protection must be verified so connected steel can be assured of developing ductility. Similarly, structural bolting compatibility with the connected steel criteria must be verified.

Snubbers were brought up. It was suggested their connecting steel should follow the proposed steel criteria. Current practice is to use the catalog load for the mechanical portion of the snubbers to meet the "normal" and "upset" conditions, and the one-time load to meet the "faulted" condition (CCNPP has hydraulic snubbers only). It was suggested to address possible increased limits for the mechanical portion of the snubber at a later date if necessary.

Nozzles were also mentioned as an issue. With additional system flexibility, nozzles may see more load. Questions were raised concerning the evaluation of nozzles, namely, how to perform an evaluation. The comment was made that most vendors want no load on the nozzles of their equipment. Class 1 nozzles usually can't take as much load as the attached pipe or vessel wall. Some Class 2 and 3 systems were most likely done to rules similar to Section VIII, which basically states there will be no nozzle loads. It was decided to consider nozzles and snubbers as a separate issue to be addressed later if necessary. Other catalog items such as component standard supports were also mentioned and considered in a like manner.

The next part of the meeting was devoted to looking at licensing and Code issues. The UFSAR sections which allow the use of the proposed strain limit were discussed:

- UFSAR 5A2.1: Class 1 shall mean Category I (seismic).
- UFSAR 5A3.2: Class 1 systems should use the criteria and load combinations in Table 4-8.
- Table 4-8: For LOCA + SSE (load combination #3), deflection of supports is limited to maintain equipment within limits of columns 1 and 2.

ATTACHMENT 1, LICENSING AND DESIGN BASES MEETING RESULTS
(Page 4 of 4)

While Chapter 4 of the UFSAR generally refers to the reactor coolant loop, from these statements Table 4-8 is to be used for all Seismic Category I piping. The original Code in the design of the supports, AISC, does not have strain-based limits. It was stated the material in the UFSAR augmented the Code, and provides the user with steps beyond the Code. The SAR, then, has established faulted limits.

It was agreed that the techniques and criteria proposed during the meeting for the analysis of steel supports in the Pipe Rupture/LOCA + SSE condition are clearly permitted by the license. Therefore, the licensing justification should be documented when this limit is included in a engineering standard.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 1 of 7)

INTRODUCTION

This attachment provides a description of the service levels and load types appropriate to the analysis of piping systems at CCNPP.

1. SERVICE LEVELS

A. **Seismic Category I B31.1, B31.7**

Seismic Category I B31.1 and B31.7 piping systems at CCNPP Units 1 and 2 were designed for four general service levels, which have been designated in this document as Design, Level 1, Level 2, and Level 3. The loads associated with these levels are described in UFSAR Section 5A.3.1.5 and Table 4-8.

The Design Level evaluates the response of the system under the application of primary loadings from design pressure, fluid weight, and system deadweight.

Secondary stresses are evaluated based on the maximum moment range from thermal service loadings and/or anchor movements, i.e., TAM and/or OBE SAM. The Secondary Stresses and the Primary Design Level Stresses can be combined and evaluated together.

Level 1 loads are those associated with upset service operation of the plant, commonly occurring transients (relief valve discharge, transients from startup, shutdown, and trips) and those imposed by the OBE.

It should be noted that while B31.1 and B31.7 Class II and Class III systems evaluate Design and Level 1 loads separately (according to B31.1 Sections 102.3.2(d) and 102.2.4, which distinguish between design loads and occasional loads), B31.7 Class I systems are required to evaluate Design Loads in conjunction with Level 1 loads, i.e., a combination of design pressure, design weight and the OBE is required as one of the load combinations (according to B31.7 Section 1-705.1 and UFSAR Table 4-8).

Level 2 loads are those associated with emergency service operation of the plant, including both transients (relief valve discharge, transients from startup, shutdown, and trips), and those imposed by the SSE.

Level 3 loads are those associated with extreme accident (faulted) conditions at the plant, such as plant response to a worst-case pipe rupture event (LOCA). Loads associated with accident mitigation must be included, as must loads from the SSE.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 2 of 7)

B. Seismic Category II B31.1

Seismic Category II B31.1, piping systems need only satisfy Design and Level 1 loads as described above in Section 1.A, excluding any earthquake effects.

C. ASME Class 2 and Class 3

The motor-driven train of the auxiliary feedwater system was installed almost 10 years after plant startup. It was constructed to a different set of requirements, the ASME BPV Code Section III (1977). Due to the lack of CCNPP documentation concerning the service levels used in the evaluation of the motor-driven AFW system, it is recommended that the analyst review the original calculation for this system before proceeding with an analysis. "AFW Design Criteria" (Bechtel) indicates that load combinations involving earthquake effects was taken from AEC Reg. Guide 1.48. Therefore, the material in this Reg. Guide has been used in establishing service levels for the motor-driven AFW system. The recommended load combinations have been expressed as Design, Level 1, Level 2, and Level 3 to provide consistency with the terminology used in this document for the original piping systems.

The Design Level is the same as for Seismic Category I B31.1 and B31.7 systems.

The regulatory position contained in AEC Reg. Guide 1.48 states:

- OBE to be considered at ASME Service Level B for pipe and supports with normal operating loads and occasional loads. This is Level 1.
- SSE to be considered at ASME Service Level C for pipe and ASME Service Level D for supports with normal operating loads and occasional loads. This is Level 2.
- SSE to be considered at ASME Service Level C for pipe and ASME Service Level D for supports with extreme accident conditions at the plant. This is Level 3.

See Attachment 4, Tables 1, 2 and 4 for additional clarification of load combinations and allowable limits.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 3 of 7)

2. LOAD DESCRIPTIONS

A. **Weight**

Weight of the piping system will include the weight of the pipe material, attached insulation or shielding, attached or inline piping components, and the weight of the fluid within. The design weight is the maximum weight of the system, e.g., when the system is completely filled with water. For those piping systems which do not operate with a liquid, e.g., steam piping, an additional weight analysis may be necessary to calculate the system loading for the hydrodynamic pressure test condition. Treat this as a test load (see code for pipe and support limits).

B. **Pressure**

The pressure used for any load case should be appropriate to the operating or transient condition being analyzed. The design, normal, and maximum pressures are listed in M-601 for each system service number.

C. **Temperature Effects**

Temperature effects will include thermal expansion/contraction of the pipe, and anchor movements imposed by the thermal movement of equipment to which the pipe is attached. In an extreme case, anchor movements from containment expansion during a LOCA will also be included.

If an analysis is performed and thermal movements are found to be excessive, these movements should be checked for interference.

All frame-type supports classified as "rigid" should be evaluated for the sliding friction force resulting from thermal growth in the longitudinal direction of the supported pipe. This friction effect should only be evaluated for normal operating loads (i.e., do not combine with transient loads or OBE/SSE). In general, the friction force should be computed as 0.3 x (weight + radial forces from thermal expansion, where applicable) and applied in the direction of thermal growth. Other approaches to evaluating frictional affects may be used if properly justified or referenced.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 4 of 7)

D. **Fluid Transient**

Fluid transients are dynamic events associated with irregular flow or interrupted flow in the pipe. Fluid hammer may result from rapid valve closure. Fluid slug results from an amount of liquid water being propelled at high speed (either by the sudden opening of a valve on a line under pressure, or the venting of steam into a closed discharge system that contained water) impacting an elbow, pipe bend, or pipe terminal end. These events are usually evaluated by time-history methods.

E. **Relief/Safety Valve Discharge**

When a relief or safety valve discharges, the fluid initiates a jet force that is transferred through the piping system. If the valve vents to atmosphere, the jet force may be calculated and applied to the system as a constant load. If the valve vents to a closed discharge system, transient conditions may develop (such as the generation of a fluid slug) which may require time-history analysis.

F. **Earthquake Effects**

Seismic Category I piping systems must be designed to resist two levels of earthquake: OBE and SSE. Earthquakes will generate two types of loads applicable to piping systems: inertia loads (from the excitation of the piping system's mass) and anchor movement loads (from the movement of equipment or structures to which the piping system is attached).

Use the response spectrum method for the seismic analysis of piping systems, unless alternative techniques, i.e., time-history analysis are approved. The spectrum provides values of acceleration (response) plotted against natural frequency for a series of damping values and a ductility value of one. Code Case N-411 damping may be used for all new or revised piping system analyses. If spectra for the SSE are not available, they may be calculated by using SSE = 1.875 OBE (the ratio for the vertical response of containment is less in several cases).

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 5 of 7)

When analyzing a system for the effects of seismic inertia ensure that all values of acceleration are enveloped for the entire frequency range. The following guidelines may be useful, but requires verification that all peaks are enveloped:

- For systems that run between floor levels, select the most conservative floor response spectrum.
- For systems that go between seismically-independent structures, use the most conservative building and elevation spectrum.

Use the SRSS approach for modal combinations and treat closely-spaced modes as addressed in AEC Reg. Guide 1.92. Total response to the three directions of motion (N-S, E-W, vertical) should also be obtained by the SRSS approach.

Evaluate seismic anchor movement for the piping system if one or more of the following exist:

- The piping system is run between two seismically independent structures.
- The piping is attached to large equipment or internal structures which have the capability for independent motion.
- The difference in elevation between the highest anchor point and the lowest anchor point on the piping system is greater than 40 feet and the net relative displacement between the two points is greater than 1/16th inch.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 6 of 7)

Seismically independent structures include the following:

- Main auxiliary building (upper elevations have separate east/west structures).
- Penetration area (auxiliary building).
- Diesel generator rooms (11, 12, 21, 22).
- Containment building.
- Intake structures (pumphouse, divided into north/middle/south substructures).

Equipment and internal structures having the capability for independent motion are:

- Containment internal structure (floors are fixed to internal structures, and slotted at shell).
- Reactor vessel.
- Reactor coolant pumps.
- Reactor coolant loop, pressurizer.
- Steam generators.

G. **Pipe Rupture**

Failure scenarios in the different piping systems at the plant that might result in a LOCA or otherwise affect the performance of other systems in their ability to perform a specified safety function must be evaluated to ensure that overall plant safety will not be jeopardized.

Pipe break/crack locations (for the consideration of the design and placement of pipe whip restraints, jet impingement barriers and missile protection) are postulated based on system geometry and pipe stress levels.

ATTACHMENT 2, SERVICE LEVELS AND LOAD TYPES
(Page 7 of 7)

The following lists hypothetical break locations:

- Terminal ends/anchor points.
- Any intermediate locations between terminal ends where either the sum of primary and secondary circumferential or longitudinal stresses derived on an elastic basis under the loads associated with seismic events and operational plant conditions exceeds 0.8 (S_h + S_A), or the secondary circumferential or longitudinal stress exceeds 0.8 S_A.

Two additional intermediate locations are selected based on the points of high stress as identified by UFSAR Chapter 10A. No breaks occur in short pipe runs of 5 pipe diameters or less in length.

A critical crack defined as one-half the pipe diameter in length and one-half the pipe wall thickness in width is postulated to occur at any location. Since a crack is postulated to occur anywhere, select locations having the most adverse effect on plant safety.

Pipe breaks and/or cracks are postulated to occur in piping (greater than 1" nominal size) of high energy systems, which are defined as those fluid systems where either of the following process conditions are maintained during normal plant conditions:

- Maximum operating temperature exceeds 200° F.
- Maximum operating pressure exceeds 275 psig.

Normal plant conditions are defined as normal steady state or hot standby (Modes 1, 2, 3).

Piping systems that contain fluids above atmospheric conditions but below high energy conditions during normal plant conditions are classified as moderate energy. Pipe breaks and/or cracks are not postulated in moderate energy systems at CCNPP.

Additional information may be found in UFSAR Section 10A and Mechanical Design Criteria Appendix A.

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 1 of 9)

Pipe Stress Legend for B31.1 (1967)

P	=	Pressure, psi.
M	=	Resultant moment, lb.-in.
i	=	Stress intensification factor (see page B31.1 Appendix D).
D	=	Outside diameter of pipe, in.
d	=	Inside diameter of pipe, in.
t	=	Wall thickness, in.
y	=	See B31.1 Table 104.1.2 (a) 2.
E	=	Joint efficiency (see B31.1 Table 102.4.3).
Z	=	Section modulus of pipe, $in.^3$
$S_{LOCAL\ H}$	=	Appropriate local hoop stress from contact forces and attachments, psi.
$S_{LOCAL\ L}$	=	Appropriate local longitudinal stress from contact forces and attachments, psi.
S_h	=	Allowable stress at temperature, psi (B31.1 pipe use B31.1 Appendix A Table A1 and Table A2; B31.7 Class II pipe use B31.7 Appendix A Table A8; B31.7 Class III pipe use B31.7 Appendix A Table A8 and A9).
S_D	=	S_y for carbon steel and 1.2 S_h for stainless steel (see UFSAR Table 4-8).
S_L	=	$S_y + 0.33 (S_u - S_y)$ (see UFSAR Table 4-8).
S_y	=	Yield strength of material at temperature, psi (see ASME, 1967).
S_u	=	Tensile strength of material at temperature, psi (see ASME, 1967).
S_A	=	$f(1.25 S_c + 0.25 S_h)$.
S_c	=	Allowable stress at minimum environmental temperature, psi (B31.1 pipe use B31.1 Appendix A Table A1 and Table A2; B31.7 Class II pipe use B31.7 Appendix A Table A8; B31.7 Class III pipe use B31.7 Appendix A Table A8 and A9).
f	=	Stress range reduction factor (B31.1 Table 102.3.2(c)).

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 2 of 9)

Table 1:
Primary Stress Limits for B31.1 Pipe for Design and Level 1 Conditions
(also applicable to B31.7 Class II and Class III)

		DESIGN	LEVEL 1
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING SYSTEM	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	YES
	SSE INERTIA	NO	NO
	SAFETY/RELIEF VALVE DISCHARGE	NO	YES
	FLUID TRANSIENT	NO	YES
	FAULTED (PIPE RUPTURE)	NO	NO
HOOP STRESS		$\frac{P(D-2yt)}{2tE} + S_{LOCAL\ H} \leq 1.0\ S_h$	$\frac{P(D-2yt)}{2tE} + S_{LOCAL\ H} \leq 1.2\ S_h$
LONGITUDINAL STRESS		$\frac{Pd^2}{D^2-d^2} + \frac{M}{Z} + S_{LOCAL\ L} \leq 1.0\ S_h$	$\frac{Pd^2}{D^2-d^2} + \frac{M}{Z} + S_{LOCAL\ L} \leq 1.2\ S_h$

NOTES:

1. See sheet 7 for calculating moment and application of stress intensification factors.
2. B31.1 Seismic Category II pipe is only analyzed for Design and Level 1 loads, and does not consider earthquake effects.

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 3 of 9)

Table 2: Primary Stress Limits for B31.1 Pipe for Level 2 and Level 3 Conditions (also applicable to B31.7 Class II and Class III)

		LEVEL 2	LEVEL 3
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING SYSTEM	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	NO
	SSE INERTIA	YES	YES
	SAFETY/RELIEF VALVE DISCHARGE	YES	YES
	FLUID TRANSIENT	YES	YES
	FAULTED (PIPE RUPTURE)	NO	YES
HOOP STRESS		$\frac{P(D-2yt)}{2tE} + S_{LOCAL\,H} \leq 1.0\,S_D$	$\frac{P(D-2yt)}{2tE} + S_{LOCAL\,H} \leq 1.0\,S_L$
LONG. MEMBRANE STRESS		$\frac{PD}{4t} + S_{LOCAL\,L} \leq 1.0\,S_D$	$\frac{PD}{4t} + S_{LOCAL\,L} \leq 1.0\,S_L$
LONG. BENDING STRESS (3)		$\frac{M}{Z} \leq \frac{4}{\pi} S_D \cos\left[\frac{\pi}{2S_D}\left(\frac{PD}{4t} + S_{LOCAL\,L}\right)\right]$	$\frac{M}{Z} \leq \frac{4}{\pi} S_L \cos\left[\frac{\pi}{2S_L}\left(\frac{PD}{4t} + S_{LOCAL\,L}\right)\right]$

NOTES:

1. See sheet 7 for calculating moment and application of stress intensification factors.
2. Ignore these load levels for B31.1 Seismic Category II pipe.
3. Resulting value in [ ] is in radians.

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 4 of 9)

Table 3:
Secondary Stress Range for B31.1 Pipe for Level 1 Loads Sets
(also applicable to B31.7 Class II and Class III)

		LEVEL 1
MOMENT (1)	OBE SAM	YES
	THERMAL EXPANSION	YES
	THERMAL AM	YES
LONGITUDINAL STRESS RANGE (2)		$\frac{M}{Z} + \Delta S_{LOCAL\ L} \leq 1.0\ S_A$

NOTES:

1. See sheet 9 for calculating moment and application of stress intensification factors.

2. The term $f(S_h - S'_L)$ may be added to S_A, where S'_L is the primary longitudinal stress calculated in Table 1 for design loads, i.e., weight and pressure.

3. B31.1 Seismic Category II pipe does not consider earthquake effects.

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 5 of 9)

Table 4:
Pipe Supports on B31.1 (1967) Systems
(Also applicable to B31.7 Class II and Class III)

	DESIGN	LEVEL 1	LEVEL 2	LEVEL 3
WEIGHT	YES	YES	YES	YES
THERMAL EXPANSION (1)	YES	YES (2)	YES (2)	YES (2)
TAM (1)	YES	YES	YES	YES
OBE INERTIA	NO	YES	NO	NO
OBE SAM	NO	YES	NO	NO
SSE INERTIA	NO	NO	YES	YES
SSE SAM	NO	NO	YES	YES
RELIEF/SAFETY VALVE DISCHARGE	NO	YES	YES	YES
FLUID TRANSIENT	NO	YES	YES	YES
FAULTED (PIPE RUPTURE)	NO	NO	NO	YES
COMPONENT STANDARD (NEW)	ASME LEVEL A	ASME LEVEL B	ASME LEVEL D	ASME LEVEL D
COMPONENT STANDARD (OLD) (3)	ITT GRINNELL PH-74-R CATALOG	ITT GRINNELL PH-74-R CATALOG x 1.2	ITT GRINNELL PH-74-R CATALOG x 2.0	ITT GRINNELL PH-74-R CATALOG x 2.0
SUPPORT STEEL	AISC 7th	AISC 7th x 1.2	YIELD (4)	DEFLECTION CONTROLLED (5)

See notes 1-5 on the following page.

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 6 of 9)

Table 4:
Pipe Supports on B31.1 (1967) Systems
(Also applicable to B31.7 Class II and Class III)

NOTES:

1. Ignore for snubbers unless travel is exceeded.

2. Neglect friction effects when condition involves dynamic loads.

3. The following exceptions apply:

   - Rigid Grinnell struts use Level D allowable from ITT Grinnell LCD-105 when meeting Level 2 and Level 3 loads

   - Snubbers use catalog capacity when meeting Design and Level 1 loads; "one-time allowable load" listed in catalog should be used when meeting Level 2 and Level 3 loads

   - Spring hangers should meet all load levels with the catalog capacity and should remain within the working range of the spring

4. May use AISC 7th x 1.5, with following limitations:

   - Stresses may not exceed 0.7 F_u

   - Shear stresses may not exceed 0.42 F_u

   - Buckling load may not exceed 2/3 critical buckling load

5. F_u limit compared to elastically calculated stresses. See Attachment 6.

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 7 of 9)

1.0 Combined Moment for B31.1 (1967) Primary Stress Evaluation

The moment combination technique used in this section is based on that described in B31.1 (1967) Section 119.6.4(a). The square-root-sum-of-the-squares (SRSS) approach of combination of cyclic dynamic loads is described in AEC Reg. Guide 1.92.

The combination should be carried out as follows:

a. Combine all moments from cyclic dynamic loads (seismic inertia, fluid hammer) by the SRSS approach. This is illustrated as follows:

	CYCLIC #1	CYCLIC #2	$\Sigma 1$
M_1	+4	+1	$\sqrt{4^2+1^2}=4.1$
M_2	-6	+10	$\sqrt{(-6^2)+(10^2)}=11.7$
M_3	+3	-7	$\sqrt{3^2+(-7^2)}=7.6$

The components M_1, M_2, M_3 will be used as the components for the net cyclic dynamic moment.

b. Combine the moments from non-cyclic dynamic loads (fluid slug, valve discharge) and static loads (weight) through algebraic summation. Use these as the components for the net non-cyclic moment.

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 8 of 9)

c. Combine the components of the net cyclic dynamic moment and the net non-cyclic moment through algebraic summation, using both positive and negative signs on the net cyclic dynamic moment. This process is illustrated below:

	NET NON-CYC.	NET CYC.	$\Sigma 1$	$\Sigma 2$
M_1	+4	±4.1	4 + 4.1 = 8.1	4 - 4.1 = -0.1
M_2	-6	±11.7	-6 + 11.7 = 5.7	-6 - 11.7 = -17.7
M_3	+3	±7.6	3 + 7.6 = 10.6	3 - 7.6 = -4.6
	$\sqrt{M_1^2 + M_2^2 + M_3^2} =$		14.5	18.3

The largest resultant moment of column $\Sigma 1$ or $\Sigma 2$ is the moment to be used when checking primary stress. In this example, it would be the moment from column $\Sigma 2$.

d. Apply appropriate stress intensification factor "i" to the components of the resultant bending moment on the pipe cross section, and combine with the torsional component as shown:

$$M = \sqrt{(iM_1)^2 + (iM_2)^2 + M_3^2}$$

"M" is the moment which should be used in the stress evaluation. For branches and tees, see B31.1 Section 119.6.4 (b) for combining components M_1, M_2, M_3.

ATTACHMENT 3, B31.1 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 9 of 9)

2.0 Combined Moment for B31.1 (1967) Secondary Stress Evaluation

The moment combination technique used in this section is based on that described in B31.1 (1967) Section 119.6.4(a).

Combine as follows:

a. Combine all moments from thermal expansion and thermal anchor movements by algebraic summation. Use these components as the net non-cyclic moment.

b. Combine the components of the SAM moment and the net non-cyclic moment through algebraic summation, using both positive and negative signs on the SAM moment. Also, evaluate the full range of the SAM moment. This process is illustrated below:

	NET NON-CYC.	NET CYC.	$\Sigma 1$	$\Sigma 2$	$\Sigma 3$
M_1	+4	±4.1	4 + 4.1 = 8.1	4 - 4.1 = -0.1	2 x 4.1 = 8.2
M_2	-6	±11.7	-6 + 11.7 = 5.7	-6 - 11.7 = -17.7	2 x 11.7 = 23.4
M_3	+3	±7.6	3 + 7.6 = 10.6	3 - 7.6 = -4.6	2 x 7.6 = 15.2
	$\sqrt{M_1^2 + M_2^2 + M_3^2} =$		14.5	18.3	29.1

The largest resultant moment of column $\Sigma 1$, $\Sigma 2$, or $\Sigma 3$ is the moment to be used when checking secondary stress range. In this example, it would be the moment from column $\Sigma 3$.

c. Apply appropriate stress intensification factor "i" to the components of the resultant bending moment on the pipe cross section, and combine with the torsional component as shown:

$$M = \sqrt{(iM_1)^2 + (iM_2)^2 + M_3^2}$$

"M" is the moment which should be used in the stress evaluation. For branches and tees, see B31.1 Section 119.6.4(b) for combining components M_1, M_2, M_3.

ATTACHMENT 4, ASME CLASS 2 AND CLASS 3 PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 1 of 8)

Pipe Stress Legend for ASME Class 2 and Class 3 Systems

P	=	Pressure, psi.
M_A	=	Resultant static moment, lb.-in.
M_B	=	Resultant dynamic moment, lb.-in.
M_C	=	Resultant moment from expansion and anchor movements, lb.-in.
M_D	=	Resultant moment from an unrepeated anchor movement, lb.-in.
i	=	Stress intensification factor (see NC-/ND-3673).
D	=	Outside diameter of pipe, in.
d	=	Inside diameter of pipe, in.
t	=	Wall thickness, in.
y	=	See NC-/ND-3641.1.
Z	=	Section modulus of pipe, $in.^3$
$S_{LOCAL\ H}$	=	Appropriate local hoop stress from contact forces and attachments, psi.
$S_{LOCAL\ L}$	=	Appropriate local longitudinal stress from contact forces and attachments, psi.
S_h	=	Allowable stress at temperature, psi (NC uses ASME Appendix I Table I-7.0; ND uses ASME Appendix I Table I-7.0 or I-8.0).
S_A	=	$f(1.25\ S_c + 0.25\ S_h)$.
S_c	=	Allowable stress at minimum environmental temperature, psi (NC uses ASME Appendix I Table I-7.0; ND uses ASME Appendix I Table I-7.0 or I-8.0).
f	=	Stress range reduction factor (ASME NC/ND Table 3611.2(e)-1).

ATTACHMENT 4, ASME CLASS 2 AND CLASS 3 PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 2 of 8)

Table 1: Primary Stress Limits for ASME Class 2 and Class 3 Pipe for Design and Level 1 Conditions

		DESIGN	LEVEL 1
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	YES
	SSE INERTIA	NO	NO
	SAFETY/RELIEF VALVE DISCHARGE	NO	YES
	FLUID TRANSIENT	NO	YES
	FAULTED (PIPE RUPTURE)	NO	NO
HOOP STRESS		$\frac{P(D-2yt)}{2t} + S_{LOCAL\ H} \le 1.0\ S_h$	$\frac{P(D-2yt)}{2t} + S_{LOCAL\ H} \le 1.1\ S_h$
LONGITUDINAL STRESS		$\frac{Pd^2}{D^2-d^2} + \frac{0.75iM_A}{Z} + S_{LOCAL\ L} \le 1.0\ S_h$	$\frac{Pd^2}{D^2-d^2} + \frac{0.75i(M_A+M_B)}{Z} + S_{LOCAL\ L} \le 1.2\ S_h$

NOTES:

1. See sheet 7 for calculating M_A and M_B.

ATTACHMENT 4, ASME CLASS 2 AND CLASS 3 PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 3 of 8)

Table 2:
Primary Stress Limits for ASME Class 2 and Class 3 Pipe for Level 2 and Level 3 Conditions

		LEVEL 2	LEVEL 3
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	NO
	SSE INERTIA	YES	YES
	SAFETY/RELIEF VALVE DISCHARGE	YES	YES
	FLUID TRANSIENT	YES	YES
	FAULTED (PIPE RUPTURE)	NO	YES
HOOP STRESS		$\frac{P(D-2yt)}{2t} + S_{LOCAL\,H} \leq 1.5\ S_h$	$\frac{P(D-2yt)}{2t} + S_{LOCAL\,H} \leq 1.5\ S_h$
LONGITUDINAL STRESS		$\frac{Pd^2}{D^2-d^2} + \frac{0.75i(M_A+M_B)}{Z} + S_{LOCAL\,L} \leq 1.8\ S_h$	$\frac{Pd^2}{D^2-d^2} + \frac{0.75i(M_A+M_B)}{Z} + S_{LOCAL\,L} \leq 1.8\ S_h$

NOTES:

1. See sheet 7 for calculating M_A and M_B.

ATTACHMENT 4,
ASME CLASS 2 AND CLASS 3 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 4 of 8)

Table 3:
Secondary Stress Range for ASME Class 2 and Class 3 Pipe for Level 1 Load Sets and Unrepeated Anchor Movements

		LEVEL 1	Unrepeated AM
MOMENT (1)	OBE SAM	YES	NO
	THERMAL EXPANSION	YES	NO
	THERMAL AM	YES	NO
	UNREPEATED AM	NO	YES
	LONGITUDINAL STRESS RANGE (2)	$\frac{iM_C}{Z} + \Delta S_{LOCALL} \leq 1.0\ S_A$	$\frac{iM_D}{Z} + \Delta S_{LOCALL} \leq 3.0\ S_c$

NOTES:

1. See sheet 8 for calculating M_C and M_D.

2. The term $f(S_h - S'_L)$ may be added to S_A, where S'_L is the primary longitudinal stress calculated in Table 1 for design loads (i.e. weight and pressure). This is equivalent to equation II in ASME, Sect. III (1977), Section NC-3652.3 and ND-3652.3.

ATTACHMENT 4,
ASME CLASS 2 AND CLASS 3 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 5 of 8)

Table 4:
Pipe Supports on ASME Class 2 and Class 3 Systems

	DESIGN	LEVEL 1	LEVEL 2	LEVEL 3
WEIGHT	YES	YES	YES	YES
THERMAL EXPANSION (1)	YES	YES (2)	YES (2)	YES (2)
TAM (1)	YES	YES	YES	YES
OBE INERTIA	NO	YES	NO	NO
OBE SAM	NO	YES	NO	NO
SSE INERTIA	NO	NO	YES	YES
SSE SAM	NO	NO	YES	YES
RELIEF/SAFETY VALVE DISCHARGE	NO	YES	YES	YES
FLUID TRANSIENT	NO	YES	YES	YES
FAULTED (PIPE RUPTURE)	NO	NO	NO	YES
COMPONENT STANDARD	ASME LEVEL A	ASME LEVEL B	ASME LEVEL D	ASME LEVEL D
SUPPORT STEEL	ASME SECTION III NF LEVEL A	ASME SECTION III NF LEVEL B	ASME SECTION III NF LEVEL D	ASME SECTION III NF LEVEL D

NOTES:

1. Ignore for snubbers unless travel is exceeded.
2. Neglect friction effects when condition involves dynamic loads.

ATTACHMENT 4, ASME CLASS 2 AND CLASS 3 PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 6 of 8)

1.0 Combined Moments for ASME Class 2 and Class 3 Stress Evaluations

The moment combination techniques used in this section are based on those described in NC-/ND-3652.4. The square-root-sum-of-the-squares (SRSS) approach to combination of cyclic dynamic loads is described in AEC Reg. Guide 1.92.

For branches and tees, see NC-/ND-3652.4 for combining components M_1, M_2, M_3 into the appropriate resultant.

A. Static Moment M_A.

The static moment M_A is found by combining all corresponding static loads (weight) by algebraic summation in each of the orthogonal directions and then performing the SRSS method to get the resultant moment (M_A.)

B. Dynamic Moment M_B.

1. Combine all moments from cyclic dynamic loads (seismic inertia, fluid hammer) by the SRSS approach. This is illustrated as follows:

	CYCLIC #1	CYCLIC #2	$\Sigma 1$
M_1	+4	+1	$\sqrt{4^2 + 1^2} = 4.1$
M_2	-6	+10	$\sqrt{(-6^2) + (10^2)} = 11.7$
M_3	+3	-7	$\sqrt{3^2 + (-7^2)} = 7.6$

The components M_1, M_2, M_3 will be used as the components for the net cyclic dynamic moment.

2. Combine the moments from non-cyclic dynamic loads (fluid slug, valve discharge) through algebraic summation. Use these as the components for the net non-cyclic dynamic moment.

ATTACHMENT 4, ASME CLASS 2 AND CLASS 3 PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 7 of 8)

3. Combine the components of the net cyclic dynamic moment and the net non-cyclic dynamic moment through algebraic summation, using both positive and negative signs on the net cyclic dynamic moment. This process is illustrated as follows:

	NET NON-CYC.	NET CYC.	$\Sigma 1$	$\Sigma 2$
M_1	+4	±4.1	4 + 4.1 = 8.1	4 - 4.1 = -0.1
M_2	-6	±11.7	-6 + 11.7 = 5.7	-6 - 11.7 = -17.7
M_3	+3	±7.6	3 + 7.6 = 10.6	3 - 7.6 = -4.6
	$\sqrt{M_1^2 + M_2^2 + M_3^2} =$		14.5	18.3

The largest resultant moment of column $\Sigma 1$ or $\Sigma 2$ is M_B. In this example, it would be the moment from column $\Sigma 2$.

C. Expansion/Anchor Movements Moment M_C.

1. Combine all moments from thermal expansion and thermal anchor movements by algebraic summation. Use these components as the net non-cyclic moment.

ATTACHMENT 4, ASME CLASS 2 AND CLASS 3 PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 8 of 8)

2. Combine the components of the SAM moment and the net non-cyclic moment through algebraic summation, using both positive and negative signs on the SAM moment. Also, evaluate the full range of the SAM moment. This process is illustrated below:

	NET NON-CYC.	SAM	$\Sigma 1$	$\Sigma 2$	$\Sigma 3$
M_1	+4	±4.1	4 + 4.1 = 8.1	4 - 4.1 = -0.1	2 x 4.1 = 8.2
M_2	-6	±11.7	-6 + 11.7 = 5.7	-6 - 11.7 = -17.7	2 x 11.7 = 23.4
M_3	+3	±7.6	3 + 7.6 = 10.6	3 - 7.6 = -4.6	2 x 7.6 = 15.2
	$\sqrt{M_1^2 + M_2^2 + M_3^2} =$		14.5	18.3	29.1

The largest resultant moment of column $\Sigma 1$, $\Sigma 2$, or $\Sigma 3$ is M_C. In this example, it would be the moment from column $\Sigma 3$.

D. Unrepeated Anchor Movement Moment M_D.

The range in unrepeated anchor movement moment is the range in moment from the unloaded condition to the loaded condition. M_D is determined by using the SRSS method to combine these three orthogonal moment ranges.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 1 of 11)

Pipe Stress Legend for B31.7 Class I Systems

B_1, B_2	=	Primary stress indices for component under investigation (see B31.7 Appendix D Table D-201).
C_1, C_2, C_3	=	Secondary stress indices for component under investigation (see B31.7 Appendix D Table D-201).
K_1, K_2, K_3	=	Local stress indices for component under investigation (see page B31.7 Appendix D Table D-201).
P	=	Pressure, psi.
M	=	Resultant moment due to static and dynamic loads, lb.-in.
D	=	Outside diameter of pipe, in.
t	=	Wall thickness, in.
Z	=	Section modulus of pipe, $in.^3$
y	=	0.4 (constant - see B31.7 Section 1-704.1).
$S_{LOCAL\ H}$	=	Local hoop stress from contact forces and attachments, psi.
$S_{LOCAL\ L}$	=	Local longitudinal stress from contact forces and attachments, psi.
ν	=	0.3 (Poisson's ratio).
Eα	=	Modulus of elasticity times the coefficient of thermal expansion, both at room temperature, psi/°F (B31.7 Appendix A Table A5 and Table A6).
ΔT_1	=	Range in temperature difference between the temperature of the inside surface and the temperature of the outside surface of the pipe assuming a moment-generating linear temperature distribution, °F (see B31.7 Section 1-705.3.1 for description).
ΔT_2	=	Range in temperature for that portion of the nonlinear thermal gradient through the wall thickness not included in ΔT_1, °F (see B31.7 Section 1-705.3.1 for description).
E_{ab}	=	Average modulus of elasticity between two parts of a gross structural discontinuity, psi (B31.7 Appendix A Table A6).
α_a	=	Mean coefficient of expansion on side *a* of a gross discontinuity, in./in. °F (B31.7 Appendix A Table A5).
T_a	=	Average temperature minus the room temperature on side *a* of a gross structural discontinuity, °F.
α_b	=	Mean coefficient of expansion on side *b* of a gross structural discontinuity, in./in. °F (B31.7 Appendix A Table A5).
T_b	=	Average temperature minus the room temperature on side *b* of a gross structural discontinuity, °F.
S_m	=	Stress intensity at temperature, psi (B31.7 Appendix A Table A1).
S_D	=	S_y for ferritic steels, 1.2 S_m for austenitic steels (UFSAR Table 4-8).
S_L	=	$S_y + 0.33(S_u - S_y)$ (UFSAR Table 4-8).
S_y	=	Yield strength of material at temperature, psi (see ASME (1967)).
S_u	=	Tensile strength of material at temperature, psi (see ASME (1967)).
S_{pi}	=	Peak stress intensity range for a given set of cycles, psi.
S_{Ai}	=	Alternating stress intensity for a given set of cycles, psi.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 2 of 11)

Table 1:
Primary Stress Intensity Limits for B31.7 Class I Pipe for Design + Level 1 Condition

		DESIGN + LEVEL 1
PRESSURE		YES
MOMENT (1)	WEIGHT OF PIPING SYSTEM	YES
	WEIGHT OF FLUID	YES
	OBE INERTIA	YES
	SSE INERTIA	NO
	SAFETY/RELIEF VALVE DISCHARGE	YES
	FLUID TRANSIENT	YES
	FAULTED (PIPE RUPTURE)	NO
HOOP STRESS INTENSITY		$\frac{P(D - 2yt)}{2t} + S_{LOCAL\ H} \leq 1.0\ S_m$
LONGITUDINAL STRESS INTENSITY		$\frac{B_1 PD}{2t} + \frac{B_2 M}{Z} + S_{LOCAL\ L} \leq 1.5\ S_m$

NOTES:

1. See sheet 8 for calculating moment.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 3 of 11)

Table 2:
Primary Stress Intensity Limits for B31.7 Class I Pipe for Level 2 and Level 3 Conditions

		LEVEL 2	LEVEL 3
PRESSURE		YES	YES
MOMENT (1)	WEIGHT OF PIPING SYSTEM	YES	YES
	WEIGHT OF FLUID	YES	YES
	OBE INERTIA	NO	NO
	SSE INERTIA	YES	YES
	SAFETY/RELIEF VALVE DISCHARGE	YES	YES
	FLUID TRANSIENT	YES	YES
	FAULTED (PIPE RUPTURE)	NO	YES
HOOP STRESS INTENSITY		$\frac{P(D-2yt)}{2t} + S_{LOCAL\,H} \leq 1.0\,S_D$	$\frac{P(D-2yt)}{2t} + S_{LOCAL\,H} \leq 1.0\,S_L$
LONG MEMBRANE STRESS INTENSITY		$\frac{B_1PD}{2t} + S_{LOCAL\,L} \leq 1.0\,S_D$	$\frac{B_1PD}{2t} + S_{LOCAL\,L} \leq 1.0\,S_L$
LONG. BENDING STRESS INTENSITY (2)		$\frac{B_2M}{Z} \leq \frac{4}{\pi} S_D \cos\left[\frac{\pi}{2S_D}\left(\frac{B_1PD}{2t} + S_{LOCAL\,L}\right)\right]$	$\frac{B_2M}{Z} \leq \frac{4}{\pi} S_L \cos\left[\frac{\pi}{2S_L}\left(\frac{B_1PD}{2t} + S_{LOCAL\,L}\right)\right]$

NOTES:

1. See sheet 8 for calculating moment.

2. Resulting value in [ ] is in radians.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 4 of 11)

Table 3: Primary Plus Secondary Stress Intensity Range, Peak Stress Intensity Range, and Alternating Stress Intensity for Level 1 Load Sets

		LEVEL 1
PRESSURE		YES
MOMENT (1)	WEIGHT OF FLUID	YES
	THERMAL EXPANSION	YES
	THERMAL AM	YES
	OBE INERTIA	YES
	OBE SAM	YES
	SAFETY/RELIEF VALVE DISCHARGE	YES
	FLUID TRANSIENT	YES
LONG. STRESS INTENSITY RANGE		$\frac{C_1 PD}{2t} + \frac{C_2 M}{Z} + \Delta S_{LOCAL L} + \frac{1}{2(1-\nu)} E\alpha\lvert\Delta T_1\rvert + C_3 E_{ab}\lvert\alpha_a T_a - \alpha_b T_b\rvert \le 3.0\, S_m$
PEAK LONG. STRESS INTENSITY		$S_{pi} = \frac{K_1 C_1 PD}{2t} + \frac{K_2 C_2 M}{Z} + \Delta S_{LOCAL L} + K_3\left[\frac{1}{2(1-\nu)} E\alpha\lvert\Delta T_1\rvert + C_3 E_{ab}\lvert\alpha_a T_a - \alpha_b T_b\rvert\right] + \frac{1}{1-\nu} E\alpha\lvert\Delta T_2\rvert$
ALTERNATING LONGITUDINAL STRESS INTENSITY		$S_{Ai} = 0.5\, S_{pi}$

NOTES:

1. See sheet 9 for calculating moment.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES

(Page 5 of 11)

Table 4:
Pipe Supports on B31.7 Class I Systems

	DESIGN +LEVEL 1	LEVEL 2	LEVEL 3
WEIGHT	YES	YES	YES
THERMAL EXPANSION (1)	YES (2)	YES (2)	YES (2)
TAM (1)	YES	YES	YES
OBE INERTIA	YES	NO	NO
OBE SAM	YES	NO	NO
SSE INERTIA	NO	YES	YES
SSE SAM	NO	YES	YES
RELIEF/SAFETY VALVE DISCHARGE	YES	YES	YES
FLUID TRANSIENT	YES	YES	YES
FAULTED (PIPE RUPTURE)	NO	NO	YES
COMPONENT STANDARD (NEW)	ASME LEVEL A	ASME LEVEL D	ASME LEVEL D
COMPONENT STANDARD (OLD) (3)	ITT GRINNELL PH-74-R CATALOG	ITT GRINNELL PH-74-R CATALOG x 2.0	ITT GRINNELL PH-74-R CATALOG x 2.0
SUPPORT STEEL	AISC 7th	YIELD (4)	DEFLECTION CONTROLLED (5)

(See notes on the next page)

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 6 of 11)

NOTES:

1. Ignore for snubbers unless travel is exceeded.

2. Neglect friction effects when condition involves dynamic loads.

3. The following exceptions apply:

   - Rigid Grinnell struts use Level D allowable from ITT Grinnell LCD-105 when meeting Level 2 and Level 3 loads

   - Snubbers use catalog capacity when meeting Design and Level 1 loads; "one-time allowable load" listed in catalog should be used when meeting Level 2 and Level 3 loads

   - Spring hangers should meet all load levels with the catalog capacity and should remain within the working range of the spring.

4. May use AISC 7th x 1.5, with following limitations:

   - Stresses may not exceed 0.7 F_u

   - Shear stresses may not exceed 0.42 F_u

   - Buckling load may not exceed 2/3 critical buckling load

5. F_u on elastically calculated stresses. See Attachment 6.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 7 of 11)

1.0 Combined Moment for B31.7 Class I Primary Stress Intensity Evaluation

The moment combination technique described in this section is based on B31.7 Section 1-705.1. The square-root-sum-of-the-squares (SRSS) approach to combination of cyclic dynamic loads is described in AEC Reg. Guide 1.92.

The combination should be carried out as follows:

1. Combine all moments from cyclic dynamic loads (seismic inertia, fluid hammer) by the SRSS approach. This is illustrated below:

	CYCLIC #1	CYCLIC #2	$\Sigma 1$
M_1	+4	+1	$\sqrt{4^2+1^2}=4.1$
M_2	-6	-10	$\sqrt{(-6^2)+(10^2)}=11.7$
M_3	+3	-7	$\sqrt{3^2+(-7^2)}=7.6$

The components M_1, M_2, M_3 will be used as the components for the net cyclic dynamic moment.

2. Combine the moments from non-cyclic dynamic loads (fluid slug, valve discharge) and static loads (weight) through algebraic summation. Use these as the components for the net non-cyclic moment.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 8 of 11)

3. Combine the components of the net cyclic dynamic moment and the net non-cyclic moment through algebraic summation, using both positive and negative signs on the net cyclic dynamic moment. This process is illustrated below:

	NET NON-CYC.	NET CYC.	$\Sigma 1$	$\Sigma 2$
M_1	+4	±4.1	4 + 4.1 = 8.1	4 - 4.1 = -0.1
M_2	-6	±11.7	-6 + 11.7 = 5.7	-6 - 11.7 = -17.7
M_3	+3	±7.6	3 + 7.6 = 10.6	3 - 7.6 = -4.6
	$\sqrt{M_1^2 + M_2^2 + M_3^2} =$		14.5	18.3

The largest resultant moment of column $\Sigma 1$ or $\Sigma 2$ is the moment to be used when checking primary stress intensity. In this example, it would be the moment from column $\Sigma 2$.

For branches and tees, see B31.7 Appendix D Table D-201 (5) for combining components M_1, M_2, M_3 into the appropriate resultant.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 9 of 11)

2.0 Combined Moment for B31.7 Class I Primary Plus Secondary Stress Evaluation and Peak Stress Evaluation

The moment combination technique described in this section is based on B31.7 Section 1-705.2. The square-root-sum-of-the-squares (SRSS) approach to combination of cyclic dynamic loads is described in Reg. Guide 1.92.

The combination should be carried out as follows:

a. Combine all moments from cyclic dynamic loads (seismic inertia, fluid hammer) by the SRSS approach. This is illustrated as follows:

	CYCLIC #1	CYCLIC #2	$\Sigma 1$
M_1	+4	+1	$\sqrt{4^2+1^2} = 4.1$
M_2	-6	-10	$\sqrt{(-6^2)+(10^2)} = 11.7$
M_3	+3	-7	$\sqrt{3^2+(-7^2)} = 7.6$

The components M_1, M_2, M_3 will be used as the components for the net cyclic dynamic moment.

b. Combine all moments from thermal expansion and thermal anchor movements by algebraic summation. Use these components as the net non-cyclic moment.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 10 of 11)

c. Combine the components of the SAM moment and the net non-cyclic moment through algebraic summation, using both positive and negative signs on the SAM moment. Also, evaluate the full range of the SAM moment. This process is illustrated below:

	NET NON-CYC.	SAM	$\Sigma 1$	$\Sigma 2$	$\Sigma 3$
M_1	+4	±4.1	4 + 4.1 = 8.1	4 - 4.1 = -0.1	2 x 4.1 = 8.2
M_2	-6	±11.7	-6 + 11.7 = 5.7	-6 - 11.7 = -17.7	2 x 11.7 = 23.4
M_3	+3	±7.6	3 + 7.6 = 10.6	3 - 7.6 = -4.6	2 x 7.6 = 15.2
	$\sqrt{M_1^2 + M_2^2 + M_3^2} =$		14.5	18.3	29.1

The largest resultant moment of column $\Sigma 1$, $\Sigma 2$, or $\Sigma 3$ is the net secondary moment.

ATTACHMENT 5, B31.7 CLASS I PIPE STRESS AND SUPPORT CAPACITY TABLES
(Page 11 of 11)

c. Combine the components of the net cyclic dynamic moment and the net secondary moment through algebraic summation, using both positive and negative signs on the net cyclic dynamic moment. Also, evaluate the full range of the net cyclic dynamic moment. This process is illustrated below:

	NET SEC.	NET CYC.	$\Sigma 1$	$\Sigma 2$	$\Sigma 3$
M_1	8.2	±4.1	8.2 + 4.1 = 12.3	8.2 - 4.1 = 4.1	2 x 4.1 = 8.2
M_2	23.4	±11.7	23.4 + 11.7 = 35.1	23.4 - 11.7 = 11.7	2 x 11.7 = 23.4
M_3	15.2	±7.6	15.2 + 7.6 = 22.8	15.2 - 7.6 = 7.6	2 x 7.6 = 15.2
	$\sqrt{M_1^2 + M_2^2 + M_3^2} =$		43.6	18.3	29.1

The largest resultant moment of column $\Sigma 1$, $\Sigma 2$, or $\Sigma 3$ is the moment to be used when checking primary plus secondary stress intensity range and peak stress intensity range. In this example, it would be the moment from column $\Sigma 1$.

For branches and tees, see B31.7 Appendix D Table D-201 (5) for combining components M_1, M_2, M_3 into the appropriate resultant.

ATTACHMENT 6, LEVEL 3 STRESS LIMITS FOR STEEL PIPE SUPPORTS ON SEISMIC CATEGORY 1 B31.1 AND B31.7 SYSTEMS

1.0 CRITERIA

The following strain-bounding limits on elastically calculated stresses in steel pipe supports on Seismic Category I B31.1 and B31.7 systems should be used when meeting Level 3 loads:

Tension, Compression, Bending:	less than F_u
Shear:	less than 0.5 F_u
Buckling:	less than 2/3 P_{cr}
Where:	F_u is the ultimate material stress

These limits are intended for use with ductile materials and ductile support configurations; refer to the subsequent sections in this attachment. The buckling limit is the same for that to be used when evaluating Level 2 loads; buckling is a non-ductile mode of failure and hence no further increase may be taken. When applying these limits, stresses from all sustained force loads must be kept at or below yield. For situations in which extreme support deflections result, the effect of the support compliance on the supported pipe should be evaluated.

Higher strain limits may be applied as discussed in Attachment 1 so long as the analysis methodology (plastic flow and strain hardening limits) are adequately documented and approved.

ATTACHMENT 6, LEVEL 3 STRESS LIMITS FOR STEEL PIPE SUPPORTS ON SEISMIC CATEGORY I B31.1 AND B31.7 SYSTEMS

(Page 2 of 10)

2.0 STRAIN-LIMIT BASIS

Ductility, by definition, describes the ability of a component or structural system to deform beyond its yield limit. A structure will yield locally under displacement-controlled loading, and the stresses will be readjusted to other parts of the structure. This energy absorption and deformation capacity are what prevent brittle failure under excessive loading.

For supports to be able to withstand stresses greater than yield, they must be ductile. It is important to verify the as-built dimensions and condition of the piping and support system. Not only must the supports be ductile, but the system response must be ductile. This support system must also include redundancy and inelastic load-deformation capabilities in order to provide adequate performance.

It is well documented that the piping and associated supports have the ability to withstand large displacement-controlled loads, e.g. earthquakes, without failure. From a historical and experimentally based viewpoint, the ductility of pipe supports is evident. Situations have been documented in which the building has collapsed, however the piping system remained intact, with only minor damage. Typically, seismic loads much greater than the SSE at CCNPP are necessary to cause damage to pipe supports.

Limits for extreme load conditions, i.e., pipe rupture, SSE, have been established for Seismic Category I system steel pipe supports in the CCNPP UFSAR. UFSAR section 5.A.2.1 defines class I as Category I (Seismic) structures, systems, and equipment. UFSAR section 5.A.3.2 states that class I systems and equipment, including pipe, are designed to meet the load combinations and stresses stated in UFSAR Table 4-8. UFSAR Table 4-8 states that for the case of pipe rupture and SSE, deflections of pipe supports are limited to maintain supported equipment within allowable limits. It is desirable to express a stress limit for supports which reflects the requirements of the UFSAR, but is still valid for use with a linear elastic analysis.

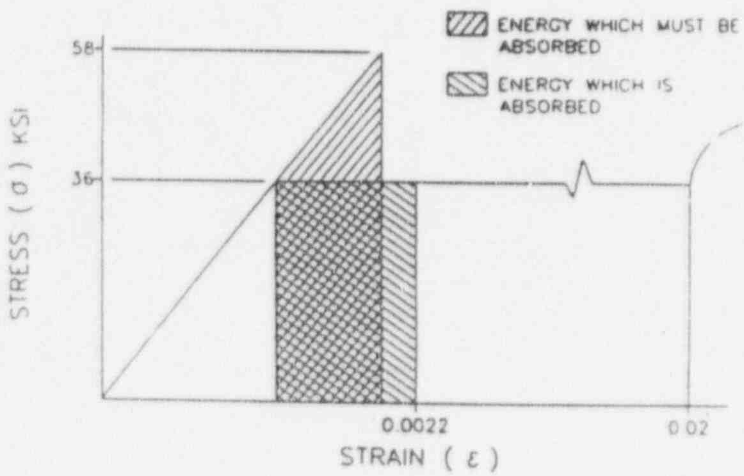
ATTACHMENT 6, LEVEL 3 STRESS LIMITS FOR STEEL PIPE SUPPORTS ON SEISMIC CATEGORY I B31.1 AND B31.7 SYSTEMS

(Page 5 of 10)

An energy balance for A36 steel, with elastically calculated stresses limited to Fu, results in a true strain of approximately 0.22% (see Figure 2.3). This results in a safety factor of almost 9 against the initiation of strain hardening (2% strain) and a safety factor of almost 90 when considering rupture (20% strain). It is important to note that stresses from sustained forces must be held below yield, and that the stress value equal to F_u is not the actual stress, but instead representative of a certain amount of permissible strain.

Figure 2.3: Energy Balance Between Actual Strain

and Elastically Calculated Stress F_u



ATTACHMENT 6, LEVEL 3 STRESS LIMITS FOR STEEL PIPE SUPPORTS ON SEISMIC CATEGORY I B31.1 AND B31.7 SYSTEMS
(Page 6 of 10)

3.0 MATERIAL DUCTILITY

Important to the energy absorption capabilities of the pipe support is the structural material. Carbon (CS) and stainless (SS) steels are very ductile and are able to undergo large deformations without failure. Materials that are considered non-ductile include cast iron and polyvinyl chloride (PVC).

Weld material is typically considered stronger than the base metal for good quality welds. Weld length and detailing become important considerations for ductile behavior. Bolt materials are similar to pipe materials. For material ductility, the following ductility factor, μ, is defined:

$$\mu = \frac{\varepsilon_f}{\varepsilon_y}$$

where:

ε_f = strain at failure

ε_y = strain at yield

μ values greater than 70 are common for carbon and stainless steels. ASTM tests materials for their elongation properties under tensile loading. Values for different materials can be found in Table 3.1.

Table 3.1: Material Properties for Common Materials

ASTM No.	MATERIAL	F_t (ksi)	F_y (ksi)	ε_f (%)	ε_y (%)
A36	Structural Steel	58	36	23	0.12
A307	CS Standard Fasteners	60	35	18	0.12
A325	High Strength Bolts	105	81	14	0.28
A490	High Strength Bolts	150	130	14	0.45
A106 B	CS Pipe for High Temperature Service	60	35	22	0.12

Therefore, higher strength materials sacrifice ductility for a higher yield strength. Even so, the high strength materials have sufficient ductility to withstand large strains.

ATTACHMENT 6, LEVEL 3 STRESS LIMITS FOR STEEL PIPE SUPPORTS ON SEISMIC CATEGORY I B31.1 AND B31.7 SYSTEMS
(Page 7 of 10)

4.0 SYSTEM DUCTILITY

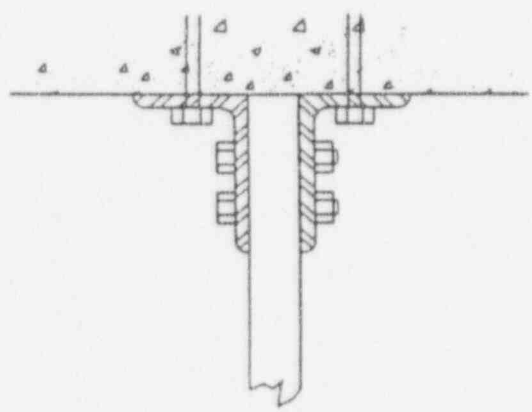
Another important aspect of support ductility is the structural system response during a strain-controlled loading. The support should behave in such a manner that the support is able to yield and continue to support loads without brittle failure. Two considerations include support configuration and detailing.

4.1 Support Configuration

Supports designed to AISC and AWS standards can be considered ductile if good workmanship and detailing are provided. Anchorage is typically designed stronger than the support; hence, the support is the weaker element of the system. A plastic hinge forms in the support member before the anchorage yields. Therefore, no further load can be transferred to the anchorage. Examples of when this condition does not exist include concrete cracking, corrosion, missing bolts or anything else limiting the design strength of the anchorage.

Essentially supports fall into two categories: pinned (rotations allowed) and fixed (moment-resisting) supports. Pinned connections typically are ductile, such as rod hangers. However, short rod hangers with heavy loads (especially fixed at the connection to the structure) are non-ductile. Moment-resisting connections vary in degree of fixity. Strut connections, including the use of clip angles, are ductile.

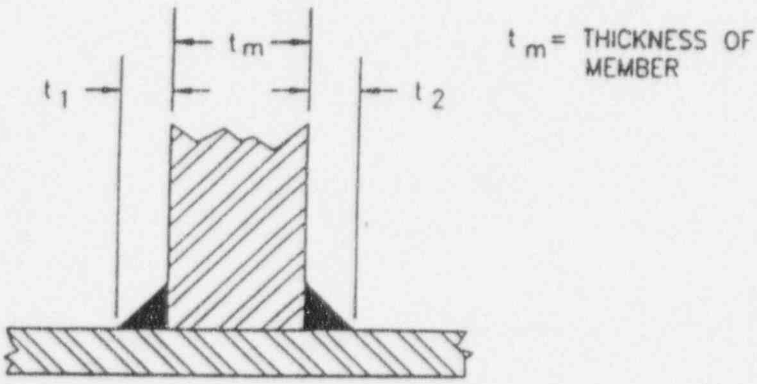
Figure 4.1.1: Ductile Strut Connection



ATTACHMENT 6, LEVEL 3 STRESS LIMITS FOR STEEL PIPE SUPPORTS ON SEISMIC CATEGORY I B31.1 AND B31.7 SYSTEMS
(Page 8 of 10)

Moment frame welded supports are suspect in terms of ductility. For a check of ductility, ensure the anchorage is adequate and use the following weld check:

Figure 4.1.2: Welded Support



If the combined throat thickness is greater than the member thickness, the connection can be considered ductile using the following evaluation from SQUG's GIP for USIA46:

$$0.707\ (t_1 + t_2) > t_m$$

Weld lengths found from AISC or AWS requirements and detailed according to established procedures are strong enough to withstand loads associated with stresses greater than the yield stress (F_u for A36 steel).

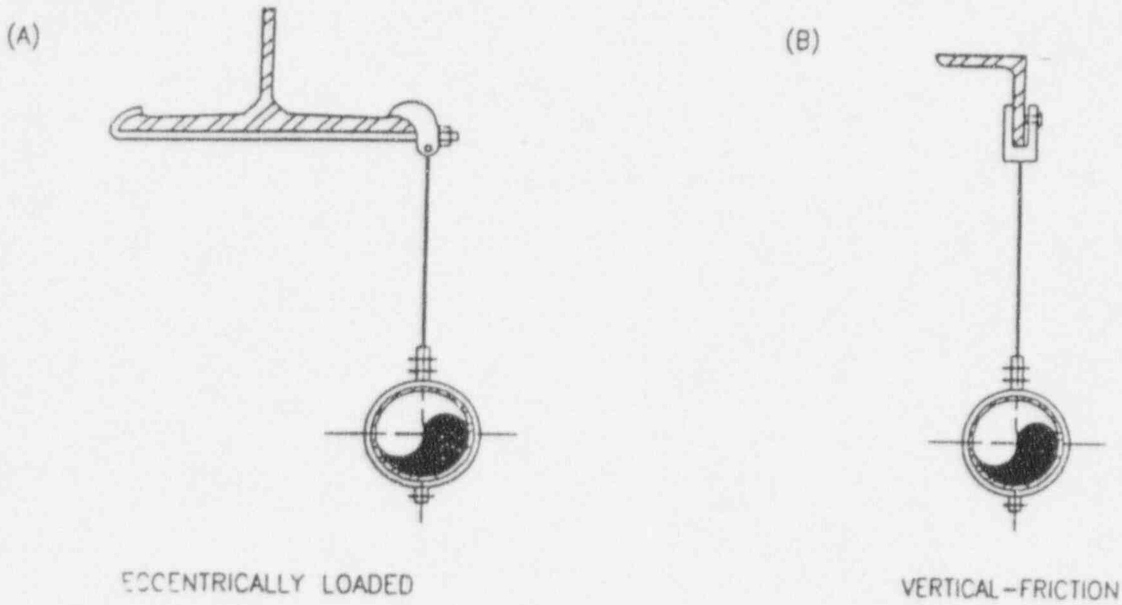
4.2 Support Detailing

Detailing of the support is important to ensure adequate strength and adequate ductility to absorb energy and withstand deformations beyond yield. As mentioned earlier, weld lengths are adequate for ductility if constructed according to established procedures. Weld cracking obviously places the support ductility into question. Because of the ductile nature of weld materials, a crack can be considered as a decreased length, if the remaining weld is in sound condition. The same procedure can be followed as that of the support anchorage. If the weld length is sufficient such that the member becomes plastic before the weld yields, the support is adequate for ductility requirements.

ATTACHMENT 6, LEVEL 3 STRESS LIMITS FOR STEEL PIPE SUPPORTS ON SEISMIC CATEGORY I B31.1 AND B31.7 SYSTEMS
(Page 9 of 10)

For bolted connections, adequate bolt spacing and edge distance can be checked to ensure adequate ductility. Clamp orientation is important. Two non-ductile orientations are as follows:

Figure 4.2.1: Non-Ductile Clamp Orientations



ATTACHMENT 6, LEVEL 3 STRESS LIMITS FOR STEEL PIPE SUPPORTS ON SEISMIC CATEGORY I B31.1 AND B31.7 SYSTEMS

(Page 10 of 10)

5.0 LOW CYCLE FATIGUE

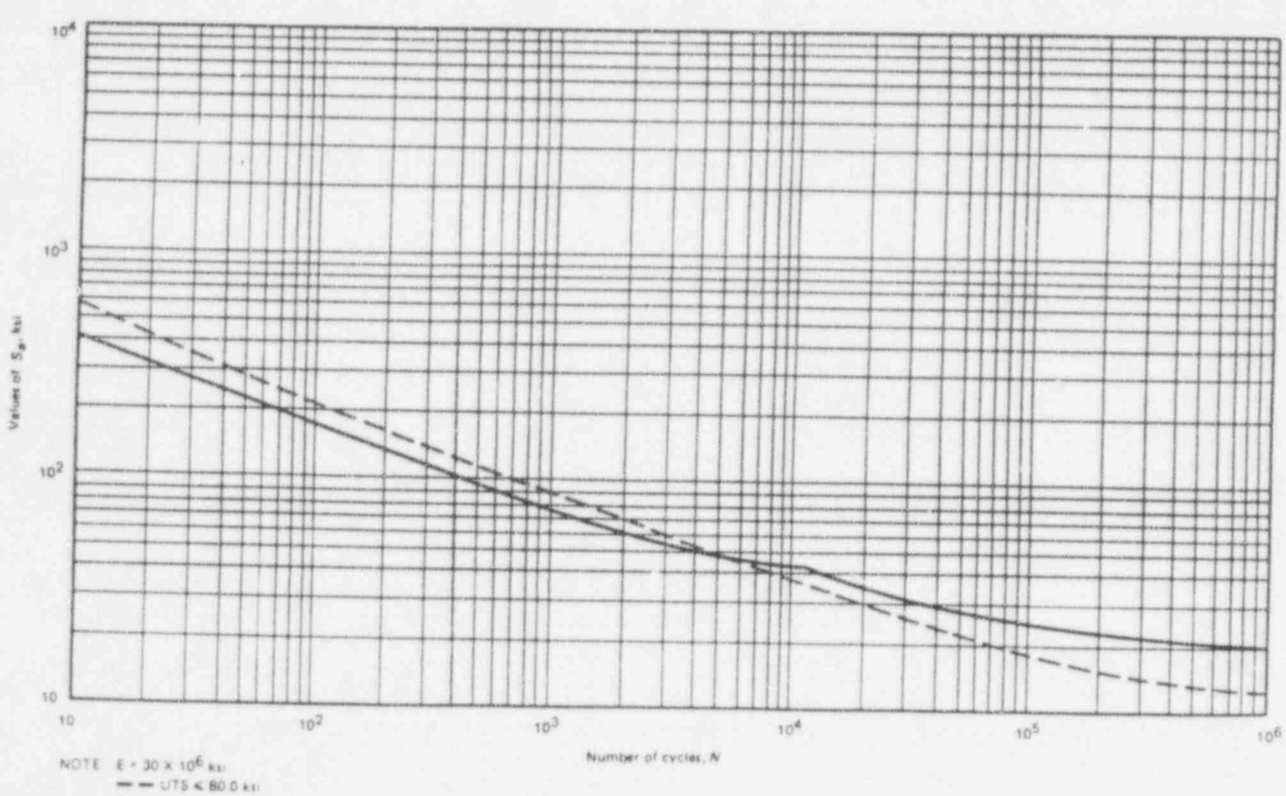
When allowing alternating plastic strains, low cycle fatigue becomes an issue. Thes alternating strains are limited to ductile supports since non-ductile supports will fail in a brittle manner under plastic strains. Fatigue stresses representative of these strains can be checked against the allowable peak stresses listed in ASME Section III Appendix I. The maximum stress amplitude from a linear elastic analysis is limited to F_u or 58 ksi for A36 steel. Choosing a typical stress intensification factor i=2.5, the peak stress amplitude is:

$$S_A = 2.5 \times 58 = 145 \text{ ksi}$$

From examination of the fatigue curve in Figure 5.1, this results in an estimated 200 cycles of S_A = 145 ksi for crack initiation in carbon steel. Provided the reduction in fatigue life from other cyclic loads is small, low cycle fatigue for this case is not a concern. Configurations with higher stress intensification may need to have fatigue addressed as part of the Level 3 evaluation.

Figure 5.1: Design Fatigue Curve for Carbon Steel

(ASME Section III Appendix I Figure I-9.1)



NOTE: $E = 30 \times 10^6$ ksi
— — UTS ≤ 80.0 ksi
—— UTS 115.0–130.0 ksi
Interpolate for UTS 80.0–115.0 ksi

CABLES & EQ

OVERVIEW OF CABLES & EVALUATION PROCESS

POTENTIAL/PLAUSIBLE AGING MECHANISMS

EVALUATION PROCESS DETAILS

THERMAL SCREENING PROCESS

RESULTS OF EVALUATION

AGING MANAGEMENT OF CABLES

EQ EQUIPMENT

QUESTIONS

Attachment 4

ALL CABLES
w/o LR PRE-SCREENING

REASONS FOR COMMODITY EVALUATION OF ALL CABLES

Original Cables at CCNPP purchased as Safety-Related, without regard to application or system resulting in a common set of cables for a broad range of applications across the site.

Cable & Service Types and Aging Processes Independent of System.

Inclusion of All Cables provides Assurance against Loss of Data by Omisssion.

Pre-screening would not yield benefits, commensurant with effort, such as elimination of cable types except in limited cases such as PVC and Teflon and unspecified cable types.

REFERENCES

(1) - CCETS (Calvert Cliffs Electrical Tracking System)

(2) - Digital Engineering System 1000

(3) - IEEE Standard 101 - 1987, "IEEE Guide for the Statistical Analysis of Thermal Life Test Data"

(4) - EPRI NP-4172SP, "Radiation Data for Design and Qualification of Nuclear Plant Equipment"

(5) - EPRI TR-103841, "Low-Voltage Environmentally-Qualified Cable License Renewal Industry Report"

(6) - DOE, "Cables & Terminations Aging Management Report" (DRAFT)

(7) - ES-014, "Summary of Ambient Environmental Service Conditions used at Calvert Cliffs Nuclear Power Plant"

(8) - EQ Files (Calvert Cliffs)

PROJECT PARTICIPANTS

Plant Support Engineering Section of CCNPPD

EQ Project

Electrical Engineering Unit of NED

Plant Testing Unit of CCNPPD

Life Cycle Management Unit of NED

CABLES

STARTING POINT

CCETS Report which included all scheduled cables.

CABLES & SERVICE TYPES

Insulating Material	Power	Cntrl	Instr
Silicone Rubber	X	X	X
XLPE	X	X	X
EPR	X	X	X
Mineral	X	---	X
Kapton	---	---	X
Fiber Optic	---	---	X
Teflon	---	---	X
PVC	---	X	X
Misc	X	X	X

CABLES

NOTES RELATIVE TO CABLE POPULATION AT CCNPP

Over 80% of scheduled cables are silicone rubber insulated.

Silicone Rubber insulated cables do not undergo significant thermal aging during 60 years of service at CCNPP due to plant specific derate practice.

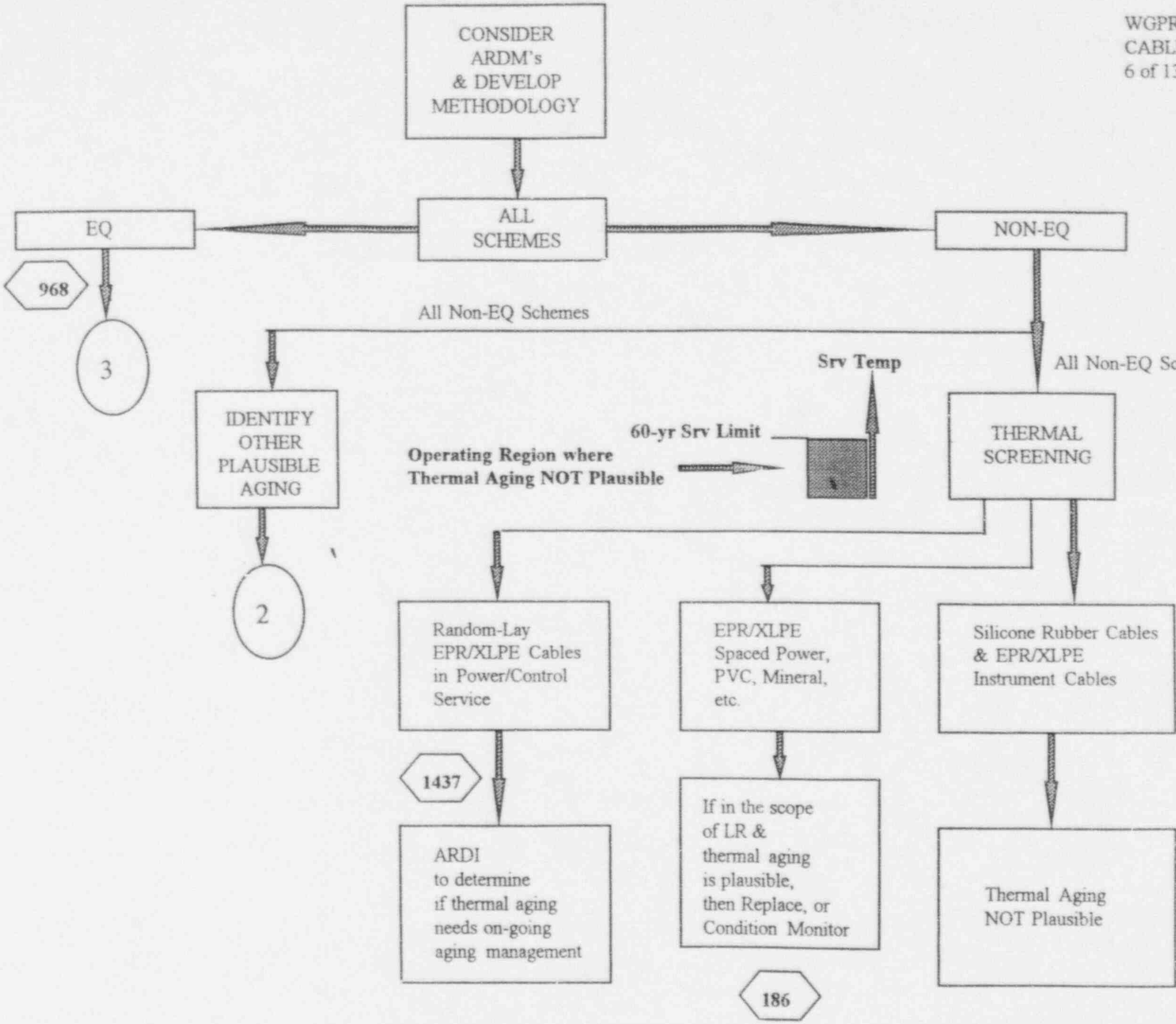
Mineral insulated cables do not undergo significant thermal aging during 60 years of service at Calvert Cliffs.

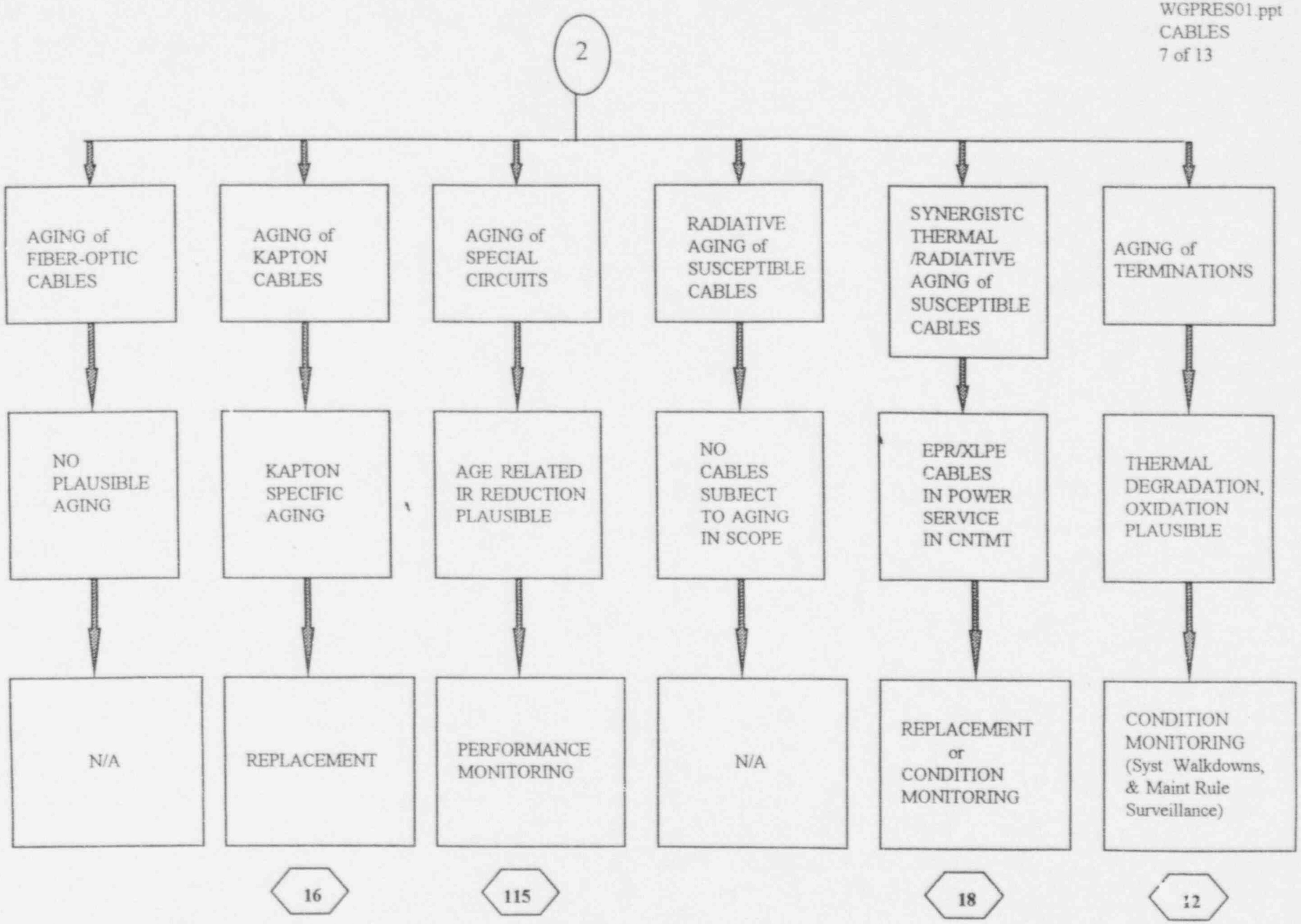
With the exception of (2) cables, there are no PVC, Teflon, or Misc insulated cables at CCNPP which are in the scope of LR.

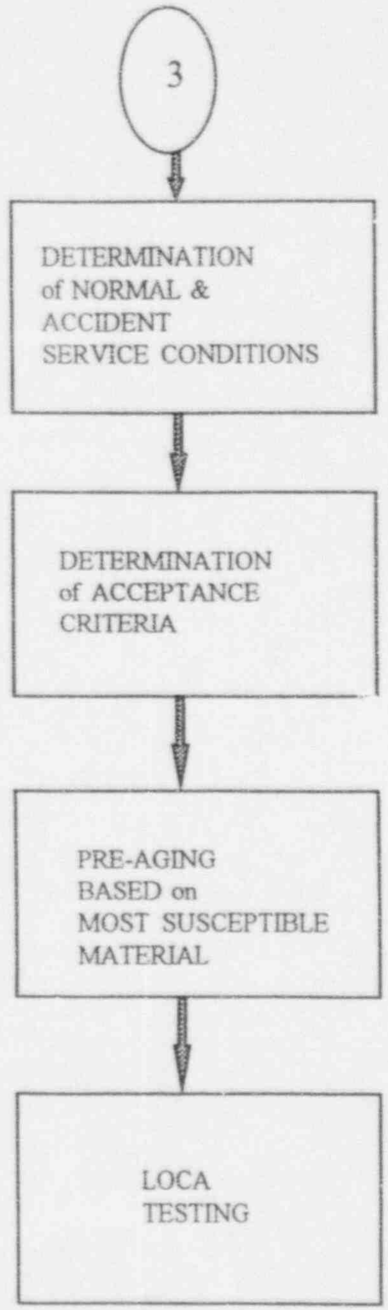
POTENTIAL/PLAUSIBLE AGING MECHANISMS

ARDM	*PLAUSIBLE*	*NOTE*
Mechanical Stress	NO	Precluded by Installation Practices
Electrical Stress	NO	Precluded by Derating & Design
Water Treeing	NO	XLPE not used in High Voltage Applications
Radiation Stress	NO	No Teflon Cables are in the scope of LR
Thermal Aging	YES	non-Silicone Rubber Power & Control Cables
Kapton Specific Aging	YES	Kapton Cables in Cntmt
Radiative Clouding	NO	In-scope F.O. Cables in low Rad Environment
IR Reduction	YES	Certain non-Silicone Rubber Instrument Cables
Synergistic Thermal/Radiative Aging	YES	EPR/XLPE Power Cables in Cntmt
Chemical Attack	NO	Exposure to Degrading Chemicals not Normal

References 4-6


CONSIDER ARDM's & DEVELOP METHODOLOGY
ALL SCHEMES
EQ
NON-EQ
968
3
All Non-EQ Schemes
All Non-EQ Schemes
IDENTIFY OTHER PLAUSIBLE AGING
2
Srv Temp
60-yr Srv Limit
Operating Region where Thermal Aging NOT Plausible
THERMAL SCREENING
Random-Lay EPR/XLPE Cables in Power/Control Service
EPR/XLPE Spaced Power, PVC, Mineral, etc.
Silicone Rubber Cables & EPR/XLPE Instrument Cables
1437
ARDI to determine if thermal aging needs on-going aging management
If in the scope of LR & thermal aging is plausible, then Replace, or Condition Monitor
Thermal Aging NOT Plausible
186


2
AGING of FIBER-OPTIC CABLES
AGING of KAPTON CABLES
AGING of SPECIAL CIRCUITS
RADIATIVE AGING of SUSCEPTIBLE CABLES
SYNERGISTC THERMAL /RADIATIVE AGING of SUSCEPTIBLE CABLES
AGING of TERMINATIONS
NO PLAUSIBLE AGING
KAPTON SPECIFIC AGING
AGE RELATED IR REDUCTION PLAUSIBLE
NO CABLES SUBJECT TO AGING IN SCOPE
EPR/XLPE CABLES IN POWER SERVICE IN CNTMT
THERMAL DEGRADATION, OXIDATION PLAUSIBLE
N/A
REPLACEMENT
PERFORMANCE MONITORING
N/A
REPLACEMENT or CONDITION MONITORING
CONDITION MONITORING (Syst Walkdowns, & Maint Rule Surveillance)
16
115
18
12


3
DETERMINATION of NORMAL & ACCIDENT SERVICE CONDITIONS
DETERMINATION of ACCEPTANCE CRITERIA
PRE-AGING BASED on MOST SUSCEPTIBLE MATERIAL
LOCA TESTING

CABLES SCREENING CRITERIA

Thermal Aging Screen: **Arrenhius based T(60) < Operating Temp**	EPR or XLPE cables in power or control service, No PVC cable in scope
Radiative Aging Screen: **Radiation Damage Threshold < 1.5 MRad**	No Teflon cable in scope
Kapton Aging Screen: **Kapton inside Containment** (Kapton under mechanical stress in hot, wet environment)	16 cables
Synergistic Rad/Thermal Aging Screen: **EPR or XLPE insulated power service cable in containment**	18 cables
IR Reduction Screen: **EPR or XLPE instrument cables servicing wide dynamic range instruments**	115 cables
Split Jacket Screen: **EQ cable, EPR insulated with bonded Hypalon jacketed used in containment**	CBL018 not used in containment CBL038 is SIS wire (not jacketed) WRNMS1 includes this config CETX01 includes this config

THERMAL SCREENING

(1) Determine a 60 year service limiting temperature for each insulation material in use.

Dielectric Failure may result if a cable is continuously exposed to temperatures at or above this limit for 60 years.
Arrenhius methodology (Ref 3) applied to conservative selection from System 1000 data-base (Ref 2)

(2) Determine upper bound on operating service temperature of cable in normal service.

Determine maximum ambient temperatures to which cables are exposed based on plant temperature surveys (Ref 7)

Maximum ambient temperature is 160F (Main Steam Piping Penetration Room)

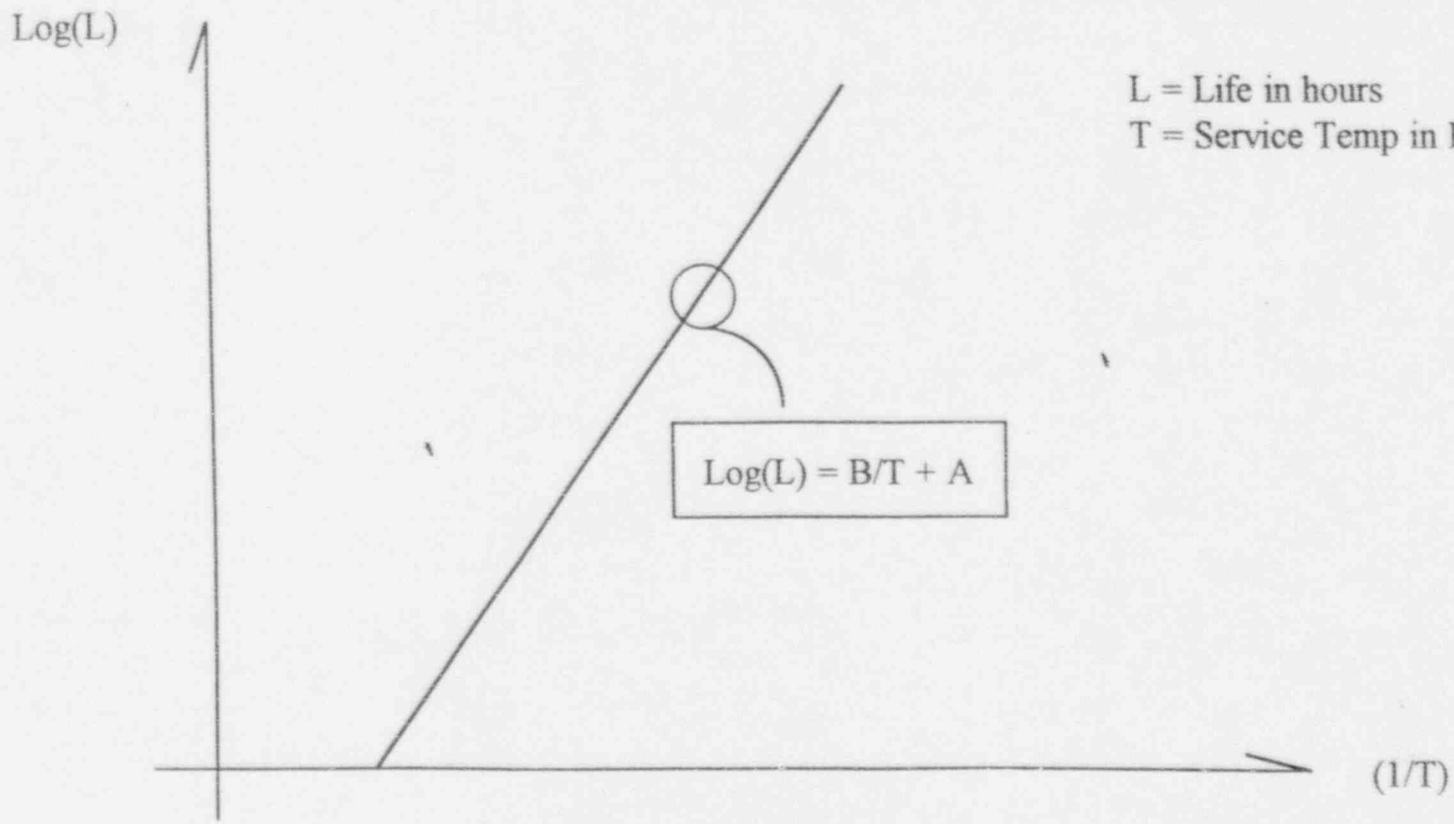
Evaluate ohmic heating of the cable.

Ohmic Heating of Instrumentation Cables negligible.
Ohmic Heating of Spaced Power Cables determined by IPCEA model.
Upper Bound on Operating Service Temperature of Unspaced (Random Lay) Power and Control Cables Determined Empirically.

(3) If operating service temperature exceeds the 60 year service limiting temperature, then thermal aging is plausible and must be managed.

CABLES

ARRENHIUS METHODOLOGY



L = Life in hours
T = Service Temp in K

Method 1: $\log(L) = (B/T) + A$ $K = A$

Method 2: $\ln(L) = (B/T) + \ln(A)$ $K = \ln(A)$

Material	Source	Criteria	K	B	60yr Temp	Notes
EPR	Phase 1, UESC Syst 1000	20% Retention of Elongation, Margin of Safety to Dielectric Failure	-9.601	5484.0914	184F	Method 1, Chosen Act. Enrgy = 1.06eV (1.05eV lowest of 20 data sets)
EPR	CBL038	50% Retention of Elongation	-11.597	6226.8	188F	Method 1
EPR	CBL001	100% Retention of Elongation	-16.61	8123.92	195F	Method 1
SR	Phase 1, UESC Syst 1000	Dielectric Failure	-11.508	7252.9355	298F	Method 1, Chosen Act. Enrgy = Lowest
SR	CBL009	50% Retention of Elongation	-38.444	20943.4758	271F	Method 2
SR	CBL019	100% Retention of Elongation	-12.919	10310.62225	252F	Method 2
XLPE	Phase 1, UESC Syst 1000	Dielectric Failure	-7.714	4791.7286952	182F	Method 1, Chosen Act. Enrgy = Lowest
XLPE	CBL045	60% Retention of Elongation	-30.362	15624.9	186F	Method 2

THERMAL SCREENING

60 year service limiting temperatures:

BGE	AMG
SR > 194F (90C)	275F
EPR - 184F	185F
XLPE - 182F	181F
PVC - 112F (none in scope)	111F

Thermal Aging Not Plausible:

Silicone Rubber Cables -	23175
Mineral Insulated Cables -	135
Non-SiliconeRubber Cables in Instrument Service -	1635
Spaced Power Service EPR/XLPE Cables -	110

Thermal Aging Plausible or Validation of Upper Bound on Service Temperature Required:

Unspaced EPR/XLPE Power and Control Cables -	1437
Spaced Power Service EPR/XLPE Cables -	186

Some Cables Found to be Out of the Scope of License Renewal:

All PVC Cables -	256
Spaced Power Service EPR/XLPE Cables -	259

RANDOM-LAY PWR/CNTRL SERVICE
ARDI

Needed to assess approximately 1500 EPR, XLP cables in power and control service.

Development of an all-encompassing model to address ohmic heating of random lay cables not feasible. Consistent with the desire to be comprehensive in evaluating cables, all cables in the target group are considered whether in or out of the scope of License Renewal.

INITIAL ANALYSIS

(1) Rank all 480V power service trays by a heat transfer model which included consideration of circuit loads, ambient temperatures, cable mass, and tray covers.

(2) Identify cable trays near significant external radiant heat sources such as hot pipes.

(3) Analyze results of steps 1 and 2 and select thermal survey locations.

REFINING THERMAL SURVEY

(4) Perform a thermal survey of candidate "hot" tray locations and external radiant heat sources to find "bounding" locations for long-term operating temperature monitoring.

ON-GOING TEMPERATURE SURVEY

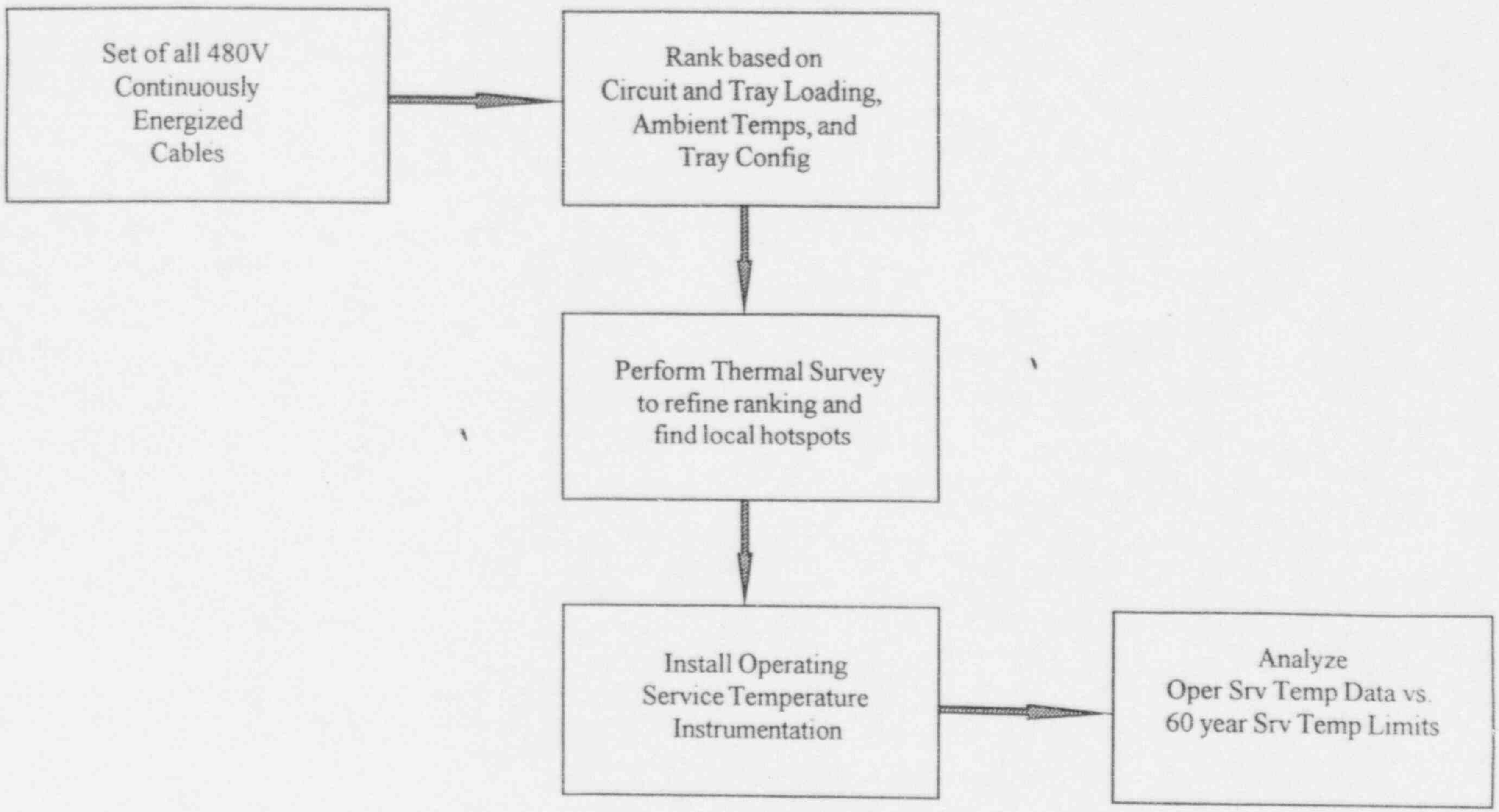
(5) Install temperature probes at "bounding" locations.

FINAL ANALYSIS

(6) Collect service temperature data over sufficient time to capture peak operating temperatures.

(7) Compare data with 60 year service limiting temperatures.

CABLES
EPR/XLPE IN RANDOM-LAY POWER SERVICE



CABLES

OTHER AGING PLAUSIBLE	**149**	Kapton cables in containment, EPR/XLPE Instr cables subject to Crit IR Reduction, EPR/XLPE Pwr cables subject to Synergistic Aging
THERMAL AGING PLAUSIBLE	**1623**	186 Spaced EPR/XLPE Power Cables, 1437 Random-Lay EPR/XLPE Power Cables Note: 18 Random-Lay Power Cables included in above group not included in this total
EQ	**968**	
NOT IN-SCOPE	**1102**	
OK	**25059**	

CABLE AGING MANAGEMENT

Replacement Prior to Period of Extended Operation

Kapton Cables in containment in fire detection service - 16

Condition Monitoring

Unspaced EPR/XLPE Power and Control Cables -	1437
Spaced Power Service EPR/XLPE Cables -	186
EPR/XLPE Cables in Power Service in Containment -	18

Replacement at End of Qualified Life

EQ Cables - 968

Performance Monitoring

EPR/XLPE Cables in Wide Dynamic Range Instrumentation Service - 115

EQ EQUIPMENT

Regulatory Basis of current EQ Program is 10CFR50.49

ELEMENTS OF CURRENT PROGRAM

(1) Identification of equipment required to be environmentally qualified per 10CFR50.49(b).

Safety-related electrical equipment which is required to perform an electrical safety function after being subjected to or while exposed to harsh environmental conditions induced by design basis events.

(2) Documentation to substantiate environmental qualification of in-scope equipment.

An Environmental Qualification Documentation File (EQ File) is maintained for each equipment group. The EQ File contains data on subparts susceptible to environmentally induced degradation, the basis of environmental qualification including acceptance criteria, test data, analysis of qualification process and anomalies, etc.

(3) Maintenance and surveillance to maintain qualification on a continuing basis.

Qualification Maintenance Requirement Sheets (QMRS) are maintained for each equipment subgroup. The QMRS identifies installation, maintenance, testing, refurbishment, and monitoring requirements necessary to maintain environmental qualification of EQ equipment.

(4) Program controlling procedures

EQ EQUIPMENT

THE FOLLOWING EQ ISSUES AFFECT LICENSE RENEWAL

(1) The CLB is to be maintained.

(2) The management of plausible aging must be demonstrated for long-lived equipment with passive functionality.

Long-lived passive device groups include cable, electrical penetrations, seals, terminal blocks, solenoid valves. The current EQ Program effectively manages the aging of organic subparts which could adversely affect the required electrical functionality of the EQ equipment.

(3) EQ is considered a TLAA by NRC.

To support conclusion that action will be taken in accordance with the CLB per 10CFR50.29, NRC staff has requested that certain information be provided.

(4) A GSI exists and must be addressed.

The GSI is documented as Issue 168 of NRC Task Action Plan. The SOC to the LR Rule (60FR22484) allows LR applicants to resolve the issue and incorporate resolution in their LRA, or justify that the CLB will be maintained until reasonable options to manage the aging become available.

EQ EQUIPMENT

TLAA

INFORMATION REQUESTED BY STAFF

(1) Evaluation Methodology

Attempted extension of qualified life by refurbishment, retest, and/or reanalysis within bounds set by EQ Program and its regulatory basis.

(2) Acceptance Criteria

Qualified Life of 60 years.

(3) Corrective Actions

Option (1): ReplaceEQ equipment at end of qualified life with identical equipment.
Option (2): Replace EQ equipment at end of qualified life with equivalent equipment.
Option (3): Replace EQ equipment at end of qualified life with new equipment.
Option (4): Use of condition-based life assessment. (FUTURE)

(4) Timing of Resolution

Program administered to ensure that environmental qualification of installed equipment is maintained. Replacements are scheduled and re-evaluations are executed in atimely manner. Environmental qualifications are not allowed to expire during the current license period and will not be allowed to expire during the period of extended operation.

EQ EQUIPMENT

GSI

PRIMARY FOCUS IS CABLES

Accelerated Aging Qualification Process

Accuracy of life predictions provided by Arrenhius methodology, i.e, is pre-aging adequate?
Limitations of using an estimated activation energy?
How does humidity affect qualification results?

Failure Mechanisms of Special Cables

Multi-conductor cables
Bonded-Jacket cables

Cable Installation and Environments

Affect on qualification of Hot-spots, Excessive Vibration, Water/steam Impingement, Physical Damage.
Affect on qualification of Bends, Overhangs, Vertical Runs, Trays, Conduits, Fire Protective Coatings, and Improper Installation.

CM Techniques

Effectiveness?
Can they be used to predict accident survivability?

License Renewal

Acceptable re-qual options?
Viability of condition-based life?
Use of operating experience?
Extension of qualified life using current qual process?

EQ EQUIPMENT
GSI

BGE RESPONSE TO GSI

BGE will continue to meet its CLB with respect to 10CFR50.49 until such time that reasonable options to manage aging become available or the issue is considered closed.
BGE will continue to follow industry developments.
BGE will respond to new regulatory requirements.

ADDITIONAL CONSIDERATIONS

Failure Mechanisms of Special Cables

BGE's acceptance criteria is directly linked to critical electrical characteristics or a known precursor to electrical property changes.

Cable Installation and Environments

BGE's cable installation practices have been and are designed to address and mitigate the effects of these issues.

License Renewal

BGE has reviewed its EQ Program and concluded that it will continue to provide reasonable assurance that intended EQ functions will be maintained consistent with the CLB during the period of extended operation.

BGE PARTICIPATION IN INDUSTRY ACTIVITIES

Member of NUGEQ

Member of EPRI

Research on Cable Aging is underway

Research on Cable Condition Monitoring proposed.

Operating Experience Unit

All SOER's received by BGE are reviewed for applicability to CCNPP.